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MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF
THE COASTS ADJOINING
RHYL, ABERGELE, AND COLWYN,

(EXPLANATION OF QUARTER-SHEET 79 N.W.)

BY

AUBREY STRAHAN, M.A., F.G.S.

(WITH NOTES BY R. H. TIDDEMAN, M.A., F.G.S.)

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

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1885.

Price One Shilling and Sixpence.

NOTICE.

THE Map, of which the present explanation furnishes a description, was originally surveyed by Messrs. W. T. AVELINE, W. W. SMYTH, and A. C. RAMSAY, and was published in 1850. The ground having recently been re-surveyed on the scale of six inches to a mile, the original Map is now withdrawn, and is replaced by a new issue reduced from the six-inch scale.

The solid rocks which occur in the district, and are described in this Explanation, range from the Wenlock Shale to the New Red Sandstone. The Silurian strata, after having been cleaved, contorted, and denuded, were covered unconformably by the Carboniferous rocks, which, in turn were disturbed before the deposition of the New Red Sandstone. There are thus two marked unconformabilities separating the Carboniferous series from the rocks above and below. An important structural feature now for the first time indicated is the great dislocation that skirts the east side of the Vale of Clwyd, and the faults connected with it.

The distribution of the Superficial Deposits is shown upon a separate edition of the Map. The most important of these, the Boulder Clay, contains an intermixture of detritus that has come from the north, and from the Welsh hills lying to the south-west and south. The Post-glacial deposits afford evidence of recent changes of level, like that met with on the coasts of Lancashire and Cheshire.

Some questions of economic importance are discussed in the following chapters, particularly the workable ores (including those yielded by the celebrated Talargoch Lead Mine) and the probability of Middle Coal-Measures occurring in the Vale of Clwyd.

ARCH. GEIKIE,
Director-General.

Geological Survey Office,
10th July 1885.

NOTICE.

THE re-survey of the area embraced in Quarter-Sheet 79 N.W. has been made—to the west of Colwyn by W. T. AVELINE; thence to the Dulas by A. STRAHAN; from the Dulas to the Clwyd, and about Rhuddlan, by R. H. TIDDEMAN; the remainder to the east by A. STRAHAN. MR. AVELINE, as District Surveyor, superintended the survey of the whole.

Two editions of the new one-inch Map are now published, one showing the drift, the other showing the solid geology; the price of each is 1*s.* 6*d.*

M.S. coloured copies of the six-inch maps are deposited for reference in the Geological Survey Office.

The Memoir has been written by MR. STRAHAN, with the addition of notes by MR. TIDDEMAN, relating to the ground for which he is responsible.

Appended is a list of works on the geology, &c. of Denbighshire and Flintshire by Messrs. WHITAKER and STRAHAN.

DR. C. LE NEVE FOSTER, Her Majesty's Inspector of Mines, has read the proofs of the Memoir, and has supplied some notes about the mines, &c. of the district.

H. W. BRISTOW,
Senior Director.

Geological Survey Office,
28 Jermyn Street, S.W.,
9th July 1885.

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THE GEOLOGY OF
THE COASTS ADJOINING
RHYL, ABERGELE, AND COLWYN.

INTRODUCTION.

THE Map now to be described includes a portion of the coast of North Wales, about 14 miles in length, extending from near the Point of Ayr to Llandrillo-yn-Rhos, near the Little Orme's Head. For the greater part of this distance the shore is formed by glacial deposits, or by the later spreads of Alluvium and Blown Sand which overlie them. In one spot only the solid rock (Carboniferous Limestone) runs out into the sea, forming the bold cliff of Craig or Penmaen on the east side of Colwyn Bay.

Inland, the eastern side of the Map is occupied by a portion of the escarpment of Millstone Grit and Carboniferous Limestone which runs southwards through Flintshire, and by the northern termination of the range of Silurian rocks which enclose the Vale of Clwyd on the east. The centre of the Map includes the wide alluvial flats and gentle boulder-clay slopes which overspread the New Red Sandstone of the Vale of Clwyd; while westwards the Limestone range of the west side of the Vale of Clwyd is shown skirting the coast from Abergele to Craig near Colwyn, where it strikes out to sea, to reappear in a distance of about three miles in the bold hills of Bryn Eurian and the Great and Little Orme's Heads.

The following table includes all those formations which are distinguished by colour on the two editions of the Map:—

Recent and Post-Glacial		Blown Sand. Alluvium. Peat. Calcareous Tufa.
Glacial*		Boulder Clay Sand and Gravel (in, under, or over Boulder Clay).
Trias	Bunter	Mottled Sandstone.
Carboniferous	Lower Coal Measures.	Sandstone. Shale.
	Millstone Grit	Shales and Sandstone (West side). Chert Beds (East side).
	Carboniferous Limestone.	Black Limestone. Limestone.
	Basement Beds	Red Conglomerate.
Upper Silurian	Wenlock Shale	Cleaved Shale with occasional Sandstone.

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* Coloured only on the edition of the map for Superficial Geology.

CHAPTER I.

SOLID GEOLOGY.

A detailed description of the physical geography of the district falls conveniently into the section of this Memoir which is devoted to an account of the Superficial Deposits. The description of the various subdivisions of the solid rocks will therefore be now proceeded with, the oldest being taken first.

UPPER SILURIAN ROCKS.

Wenlock Shale.

The Wenlock Shale consists of a great thickness of pale gray sandy shales or mudstones, with beds of fine-grained hard sandstone intercalated at various horizons. The whole series (excepting the sandstones) is cleaved, in some cases the structure being sufficiently well developed to have led to trials for slates having been made. The slates, however, are of extremely bad quality, and the quarries are all abandoned. The direction of the cleavage on the east side of the Vale of Clwyd is fairly constant at E. 10° S., while on the west side it varies from E. 45° S. to E. 5° S., showing, nevertheless, a prevalence in a direction of about E. 10° S. It is interesting to note that the very numerous synclinal and anticlinal folds into which these beds have been bent have their axes arranged parallel to the direction of the cleavage. An instance may be seen in Cwm Mountain, where the axis of an anticlinal fold is clearly shown by the form of the outcrop of a bed of sandstone. It may be inferred that the cleavage and folding were produced by the same cause, namely, pressure in the direction N. 10° E. Subsequently it will be shown that the cleavage and partial metamorphism which accompanied it were accomplished before the commencement of the Carboniferous Period.

As shown on the map the general dip of the Silurian strata on the west side of the Clwyd is towards the north-east. An observer, therefore, travelling in a south-westerly direction, while crossing many undulations, passes generally from higher to lower beds. The lower part of the Wenlock series, known as the Denbigh Grits, is finally reached in the valley of the Conway, near which it is succeeded by the Tarannon Shales and finally by the Bala Beds (Lower Silurian). The area occupied by these rocks has been described as a whole by SIR ANDREW RAMSAY.*

---

* Geology of North Wales. Memoirs of the Geological Survey, vol. iii., second edition, 1881.

CARBONIFEROUS ROCKS.

Basement Beds.

One of the greatest unconformities to be met with in the British Isles exists between the Wenlock Shale last described and the Basement Beds of the Carboniferous Series. These latter may be seen in more than one section to rest in the form of coarse conglomerates on the edges of the upturned Silurian strata, showing a discordance *apparently* as great as that which exists between the pebbly beach of a modern sea-shore and the rocks of the cliff against which it is banked. Even without such visible signs the unconformity would be inferred from the fact that a short distance west of the margin of this map the Carboniferous rocks pass suddenly on to the Lower Silurian strata, and also in Anglesea on to rocks of very early date, thus clearly indicating a great upheaval and denudation of the Silurian system in pre-Carboniferous times. In addition to this, the Carboniferous Conglomerates and Limestone, resting generally at a gentle angle on the upturned Wenlock Shale, show none of the cleavage or folding so noticeable in the older rock; while, on the other hand, the fragments of Wenlock Shale occasionally found embedded in the base of the newer series are as much metamorphosed as the parent rock itself.

It is known, however, that the phenomena of cleavage and metamorphism as displayed in the Wenlock Shale can only have been produced under certain conditions, namely, that the strata should not only have been subjected to compression in the direction N. 10° E. as before mentioned, but that they should at the time have been deep-seated; the weight and non-conducting properties of a great mass of overlying strata being essential to the production of the observed effects. This "cover" appears to have been provided in the mass of the Upper Ludlow Beds and the Tilestones, which attain a great thickness in Central Wales, and, as there is reason to believe, formerly overspread the Wenlock Shale of North Wales. For, though not found *in situ* in any part of North Wales, their débris furnished the larger part of the materials of which the Carboniferous Basement Beds are composed, as will now be shown.

The Basement Beds are extremely variable in thickness and character. On the east of the Vale of Clwyd they appear in the form of a red conglomerate with small pebbles (about half an inch long) in the lower part, and of flaggy red sandstone and red shales in the upper part. The conglomerate is seen in a lane near Pentre-cwm, and near the Cwm Iron-mine. A field above Pentre-cwm is strewn with fragments of red flags, while some old shafts in the slope above have disclosed bright red and green laminated shales. The last indication of the presence of these beds occurs at the Cwm mine, where a little laminated red shale is visible. At this point the beds are lost under the drift, but there is little doubt that the Basement Beds here thin out, leaving the limestone in contact with the Wenlock Shale, as is the case throughout Flintshire. This thickness of this subdivision between

Pentre-bach and Pentre-cwm is about 95 feet, west of Marian-bach not more than 50 feet, while at Marian it has thinned out, the rate of attenuation being about 1 in 55.

On the west side of the Vale of Clwyd the Basement Beds attain a greater development. Their occurrence near Abergele was first noticed by Mr. J. Price, by whom they were pointed out to Mr. Bowman. They were described by Mr. Bowman in 1841,[*] and in greater detail by Messrs. Strahan and Walker in 1879.[†] The beds have been repeatedly proved in the shafts sunk in search of iron-ore along the foot of the limestone escarpment, but the best exposure occurs in Ffernant Dingle,—a deep ravine about one mile south of Llysfaen, where an uninterrupted view of the lower part of the series is afforded. The upper part and junction with the limestone is seen in a farm-yard at Bryniau Cochion, where red-stained impure limestone rests conformably on green and purple shales, with rather a sharp line of demarcation.[‡] The slopes below are formed of a conglomerate of green and yellow sandstone pebbles in a red and green matrix, associated with mottled red and green shales. These are succeeded southwards by a deep-red conglomerate, which runs up the dip-slope by Pen-y-dared and Tyn-y-pwll to the top of the Ffernant Dingle, where the section is continued as follows, still in descending order:—

Section in Ffernant Dingle.

		Feet.
Carboniferous Basement Beds.	Red conglomerate	—
	Soft bright-red sandstone	10
	Coarse conglomerate	6
	Deep-red marl weathering into cubes	3
	Soft red sandstone with green blotches	3
	Deep-red clay crammed with pebbles	20
	Soft red micaceous sandstone with pebbles	6
	Impure limestone (cornstone)	1
	Hard red sandstone crammed with red and green pebbles	3
	Impure limestone (cornstone)	1
	Red shale	3
	Fine gravelly conglomerate	½
	Impure limestone (cornstone)	1½
	Conglomerate of red and green pebbles in a mottled red and green sandy matrix	12
	Impure limestone containing two beds of green sandstone pebbles in a sandy matrix	10
Wenlock Shale		—
		80

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[*] *Trans. Geol. Soc.*, ser. 2, vol. vi. p. 195.

[†] *Quart. Journ. Geol. Soc.*, vol. xxxv. p. 268.

[‡] Near this farm there are hollows in the limestone filled with a gravel composed entirely of pebbles derived from the Basement Beds. They are at a higher level than is now attained by the conglomerate in the neighbourhood, and were probably filled at an early date, before the outcrop assumed its present form. Near Tan-yr-ogof, on the east side of Llandulas, there are four caves or old water-channels in the limestone, two of which are filled with a similar gravel, now hardened into a rock, and overlaid by stalagmite and laminated cave-earth. The streams which brought the pebbles so far from their original position in the conglomerates must have had considerable volume and power, and probably flowed at a period when the drainage of the country was different. The occurrence of the pebbles here was first noticed by Mr. Trimmer.

The pebbles in these conglomerates are, as stated, red, green, or mottled, the green colour predominating towards the upper part of the subdivision. In other respects they present a remarkable uniformity. They are composed of a soft micaceous sandstone, liver-coloured when fine-grained, or purple when of a coarser texture. They split easily, and from their oval flattish shape have evidently been derived from a well-bedded flaggy sandstone. In colour and texture they resemble the Tilestones or newest Ludlow rocks as developed in Central Wales, and on the southern flanks of the Lake District mountains. The presumption that they have been derived from one of these formations is confirmed by the fact that they contain fossils of undoubtedly Upper Silurian age, and 90 per cent. of which occur in the Ludlow rocks. The following were identified by MR. ETHERIDGE.*

Orthis filosa, Sow.
„ *lunata,* Sow.
„ *elegantula,* Dalm.
„ *crispa,* M'Coy.
Chonetes striatella, = *lata,* Dalm. (abundant).
Spirifer crispus, His. (abundant).
„ *elevatus,* Dalm.
Rhynchonella Stricklandii, Sow.? or *borealis,* Schl.
Pterinea retroflexa, Wahl., or *lineata,* Goldf. (abundant).
Orthonotus.
Arca (or *Pterinea ?*)
Theca (?)
Tentaculites ornatus, Sow.
Holopella.

These fossils are found only in the pebbles. No organic remains contemporaneous with the deposit have yet been discovered.

It is noticeable that the Wenlock Shale on which the Basement Beds rest in all this neighbourhood, is conspicuous by its absence in the materials of the conglomerate, except only for a few angular fragments at the base, which have obviously been detached from the immediately underlying beds.

Taking into consideration the distance to the nearest locality where Upper Ludlow rocks and Tilestones occur *in situ* in Central Wales, and the fact that over a large part of this space the Carboniferous strata were laid down on a deeply denuded surface of Wenlock Shale or older rocks, it would seem as though the conglomerates, if derived from this direction, should have contained at least as great a proportion of Wenlock as of Ludlow débris. For the same reason it is not probable that the transportation was from the west or south-east or east. Towards the north and north-east, however, it is not improbable that these newest Silurian strata may exist at no great distance. The general dip of the Wenlock Shale is towards the north-east,—a dip which, as before mentioned, leads to the overlap of the Silurian by the Carboniferous system towards the west. If these relations are preserved beneath the Carboniferous rocks still further towards the north-east, where they are overflowed by the Irish Sea, the Ludlow rocks will naturally succeed the Wenlock Shale at no very great distance, and may have formed the source of this great mass of purple pebbles, on the supposition of the transportation having been from the north or north-east.

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* *Quart. Journ. Geol. Soc.*, vol. xxxv. p. 272. The specimens are in the Museum of the Geological Society of London.

The base of the conglomerates may be readily traced from Ffernant Dingle westwards through a small pit at about 150 yards distance, where the junction with the underlying Silurian rocks is again exposed, to Twynan-uchaf, near which the conglomeratic red and green cornstone is seen dipping towards the north-north-east at 25°; and 400 yards north-west of this farm the same bed was met with in a trial for hæmatite. At this point the boundary is lost sight of beneath the Drift, but is presumed to trend northwards, entering the present Quarter-sheet near Pen-y-dared, and running thence to the east and west fault, near which the base of brecciated cornstone is once more exposed to view. The slope below the limestone of Ty-mawr is formed of green and red conglomerates, as may be seen in numerous small sections, one of the best being in the side of the lane leading up the hill from Pen-lwys (Pile house). Near this house the position of the base is accurately fixed by the occurrence of a trial for hæmatite and a quarry in the Wenlock Shale close together. The former shows red shale and friable sandstone, or weathered cornstone, dipping northwards at 11°; the latter Wenlock Shale of the usual character dipping east-north-east at 12°. North of this point the base is concealed by Drift, but the junction of the subdivision with the limestone may be easily traced at the foot of the steep limestone cliff of Penmaen-rhos. On the west side of Colwyn Bay the Basement Beds are altogether absent.

Eastwards and southwards the Basement Beds may be followed as far as the south end of the Vale of Clwyd, forming everywhere (except where cut out by faults) a narrow belt separating the limestone from the Wenlock Shale. Their description is continued below by MR. TIDDEMAN, by whom they were surveyed. It will be noticed that the conglomeratic character is lost towards the south, where the beds consist of flaggy and ripple-marked red and green sandstones and shales:—

The Carboniferous Basement Beds east of the Dulas Valley run along the junction of 79 N.W. and S.W., and are thrown backwards and forwards by several faults; so, necessarily some of the places mentioned occur in the Quarter-Sheet south of that now described.

East of the bold limestone hill of Pen-y-corddyn-mawr a fault running nearly along the road which goes by Garth-gogof brings up the Basement Beds. Several shafts or trials for iron have been made here; one about 300 yards from the house exposed purple sandstone. This must be near the base, judging by the exposure of Wenlock Shale in the valley adjoining. In the recess of the limestone hills E.N.E. of Garth-gogof, these rocks, where weathered, show a soil of white clay with quartz pebbles, yellow sand, grey clay, &c., but no actual sections are visible. Beyond the next fault at the corner below the limestone, red marls were visible; and one-third of a mile west of Nant-ganol at the bottom of this series red and green sandstones and marls were seen resting on the Silurian Shales. At a shaft hard by were sandstones, ironstones, bad limestones (or cornstones), and a conglomerate made up of shale fragments. These beds are dipping apparently at an angle of 30° from N. 30° E. to N. 30° W.

At the base of these beds again, west of the fault which runs to the S.S.E. from near Tyddyn-uchaf, the dip appears to be at 35° to the N.N.W., but in some shafts still further to the dip the Silurian rocks again seem to be touched without going through any great thickness of Basement Beds.

Two small faults north of Ty'n-y-coed let down a tongue of limestone from the escarpment, and here also the Basement Beds consist of red and yellow shales and sandstones. Another large "drift" has been made near the base in these beds, on the left bank of the Gele. The beds are not well seen, but most of the stuff brought out consisted of a grit impregnated with hæmatite.

The Basement Beds beyond this point are well in the map to the south. Along the line of fault mentioned at Garth-gogof, about a mile from that house is seen an outlier of the Basement Beds faulted against the Wenlock Shale, and a large quantity of hæmatite was obtained from the fault. This is west of Ty'n-y-caeau.* There can be little doubt that the fault is the same.

R. H. T.

CARBONIFEROUS LIMESTONE.

(1.) *East of the Clwyd.*

This formation is easily separable in this area into an upper subdivision of thin-bedded black limestones, and a lower subdivision in which is included the great mass of nearly homogeneous grey and white beds, with the lower impure, and the upper cherty limestones.

A more detailed subdivision of the series has been made by **MR. G. H. MORTON** in the valuable papers in which he records the results of his examination of the Carboniferous Limestone and Cefn-y-fedw Sandstone [Millstone Grit] of Flintshire and

---

* Called Pen-y-coed on the One-inch Map.

Denbighshire. The classification of the limestone of this neighbourhood adopted by Mr. Morton is as follows*:—

Carboniferous Limestone	Upper Black Limestone.
	Upper Grey Limestone.
	Middle White Limestone.
	Lower Brown Limestone.

But though each of these subdivisions (excepting the Upper Black Limestone, which changes its character southwards) has been recognised by Mr. Morton through a large part of the Carboniferous outcrop in North Wales, yet the three lower present such slight lithological differences, or shade so gradually one into the other, as to be scarcely capable of being distinguished by colour on the Map. In the following description, however, the position of the beds in Mr. Morton's classification has been noted in each case.

Rising abruptly from the drift-covered plain near Prestatyn and Meliden, the grey and white limestones form a conspicuous escarpment running southwards through the whole length of Flintshire, and attaining heights of 800 to 1,000 feet above the sea. Dyserth Castle, Graig-fawr (500 feet), Moel Hiraddug (866 feet), and the Gop Hill (819 feet) are some of the most conspicuous points in the part of the county included in this Quarter-Sheet.

The abrupt termination of the limestone, and of the line of hills which mark its outcrop at the borders of the maritime plain of Rhyl and Prestatyn, is the result of a number of faults of great size, throwing the limestone far below the level of the sea, and introducing beds of later Carboniferous age. The faults resolve themselves into two principal lines of fracture;—the one, which may be called the Prestatyn fault, passes from Prestatyn in a south-westerly direction along the foot of Carreg-y-frân, and shifts the outcrop of the Black Limestone from near Prestatyn to beyond Meliden; the other, which may be called the Vale of Clwyd fault, runs at the foot of Graig-fawr, by Dyserth Waterfall, below Moel Hiraddug and Cwm Mountain, and thence up the whole length of the east side of the Vale of Clwyd. Along the whole of its course this fault throws down on the west side the limestone and later Carboniferous Beds which underlie the New Red Sandstone of the Vale of Clwyd, and may be considered one of the principal agents in the production of this remarkable Triassic outlier. From its size and important effect on the physical geography of the region it may take rank as one of the great faults of the British Isles.

In the neighbourhood of this fault the limestone is smashed up and much altered, but, at a short distance from it, assumes its ordinary character, and prevalent south-easterly strike. Following the base from near Dyserth, we find the limestone resting conformably on red conglomerates, and tending to pass down into them by an intermediate stage of impure but fossiliferous limestones, shales, and sandstones of variable tints. These beds are exposed in an old quarry between Pentre-bach and Pentre-Cwm, where the following descending section was observed:—

---

* *Proc. Liverpool Geol. Soc.*, vol. iv. p. 390.

	Ft.	Ins.
Grey crystalline limestone - - - - - -		
Shale - - - - - - -	0	1
Earthy limestone weathering into a yellow friable rock, with plant remains - - - -	1	0
Blue argillaceous limestone, weathering into spheroids	0	7
Earthy crystalline limestone, with bands of fine-grained limestone, containing *Athyris Royssii* - -	1	6
Black shale and nodular argillaceous limestone -	0	6
Massive grey limestone - - - - - -	5	0
Bituminous limestone with plant remains - -	2	6
White sandy bed and shale - - -	1	0
Bituminous limestone, full of plant remains and threads of coal at the bottom, and containing *Lithostrotion irregulare* and *Euomphalus* - -	3	0
Blue argillaceous limestone, weathering into spheroids	0	5
Green shale - - - - - - -	0	3
Hard white sandy bed (calcareous) - - -	0	8
White shaly nodular bed (a weathered argillaceous limestone) - - - - - - -	0	10
Very hard bluish crystalline limestone - -	6	0
Flaggy impure limestone - - - -	0	10
Argillaceous limestone - - - -	0	5
Yellow and green shale - - - - - -	0	3
Hard bluish limestone - - - - -	6	6
Beds not seen - - - - - - - -	6	0
Sandy and calcareous shale, with *Athyris Royssii*, and plant remains; passing up into bituminous limestone - - - - - - - -	5	6
Hard grey limestone, with *Athyris Royssii* -	5	6
Yellow calcareous shale - - - - -	1	0+
Beds not seen (about) - - - - - -	6	0
Basement Beds: red shales, flags and conglomerates.	—	
	55	4

The same beds are exposed in several old mining hillocks and small quarries about the south side of Moel Hiraddug, and near Marian. They are everywhere characterised by the impurity of the limestone, and its interstratification with shales and calcareous sandstones; and are always associated with a very fine-grained variety of limestone of a pale blue colour, a porcellanous texture, and leaving a soft yellow argillaceous residue on weathering. The most abundant fossils are the *Athyris Royssii* and the plant-remains, which appear to belong to the genus *Sphenopteris*, but are generally too obscure for recognition.* *Spirifera lineata*, Mart., *Syringopora sp.?* and *Zaphrentis sp.?* have also been observed by Mr. MORTON. The occurrence of threads of coal, plant-remains, and a coral, in the same bed, is noticeable as indicating the approaching invasion of a littoral zone by oceanic conditions.

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* These were first noticed by MR. H. G. MORTON, *British Association Report for* 1870, *Trans. of Sections*, p. 82.

These beds, and the red conglomerates beneath them, present a very striking similarity to the subdivisions of Lower Limestone Shales and Basement Beds that have been traced at the base of the Carboniferous rocks in the North-west of England. In the present district, partly from the fact that they pass up into the overlying mass of limestone, and partly because they are concealed by Drift for a great portion of their outcrop, it has not been thought advisable to separate them by colour. On the west of the Clwyd, it would be still more difficult to make any subdivision, in spite of the comparative absence of Drift.

The great mass of grey and white crystalline limestones succeed these passage beds (or Lower Limestone Shales). They are distinguished in a general way by their more massive bedding, crystalline texture, and the absence of shale or sandstone. They are exposed for a great thickness in the sides of Moel Hiraddug,* and are largely worked in quarries at the north end of the hill for building and agricultural purposes, and for mixing with other ingredients for the manufacture of hydraulic cement. The stone contains more than 98 per cent. of carbonate of lime, as shown by the following analysis†:—

Lime - - - - -	54·664
Magnesia - - - -	0·201
Silica - - - - -	0·905
Alumina - - - -	0·010
Potash - - - -	0·040
Iron oxide - - - -	0·029
Manganese oxide - - -	0·018
Humus - - - -	0·268
Carbonic acid and water - -	43·865
	100·000

A very pure limestone was formerly worked at Bryniau near Meliden for use in the Alkali Works at Prestatyn, now inactive.

The hill on which the ruins of Dyserth Castle stand is composed of limestone belonging to this part of the series.‡ A short distance to the east the same beds are intersected by a deep and picturesque ravine enclosed by vertical cliffs. The form of the ravine is determined by the intersection of a fault or strong joint, running E. 15° S. and said to contain copper, with a number of smaller joints running N. 18° W., partly open and partly filled with calc-spar. The ravine at present is nearly dry, but from its size and depth may not improbably have once formed the site of one of those great springs common in the limestone. A very powerful issue, known as the Ffynnon Asaph, and second only (in this county) to the famous St. Winifred's Well at Holywell, takes place at Marian Mill at about two-thirds of a mile distance.

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* The whole of the limestone of this hill, with the doubtful exception of some of the top, is referred by Mr. Morton, as he informs me, to his "Lower Brown" division.

† By Mr. M. A. Gage, of Rhuddlan.

‡ Referred by Mr. Morton to his "Middle White" subdivision.

Fossils are fairly abundant, but from the nature of the beds very difficult to extract. The following were noticed in a quarry at Plas-on-bach, near Marian, in beds about 500 feet above the base of the limestone:—Reef-corals (principally *Lithostrotion irregulare*), *Euomphalus*, sp.? and *Athyris ambigua*, Sow. *Spirifera lineata*, Phil. is noted by MR. MORTON as being usually one of the earliest fossils in the Carboniferous Limestone of North Wales, but in this neighbourhood *Athyris Royssii* is remarkably abundant in the lowest beds, as noted above. The plant-remains are confined to the lower impure beds of the limestone, and, as will be subsequently shown, to the highest argillaceous limestones which form a passage up into the Millstone Grit.

The upper part of the limestone is distinguished by being more cherty and less homogeneous than these massive beds,—a character that becomes still more marked in South Flintshire; it is also more fossiliferous.* The beds are exposed in numerous quarries and natural sections in the hill-side between Meliden and Prestatyn, and, though traversed by many small faults and undulations, preserve a general dip towards the east-north-east so as to present a fairly continuous ascending sequence. The massive white and grey limestones of Brynian (before alluded to) and of Nant-yr-Ogof are succeeded west of Gwaenysgor by a light brown limestone with nodules of chert. This again is overlain further north by a more thinly-bedded darker stone with more abundant chert. A large quarry in this part of the series shows in the lower part dark-brown and black limestone with thin shales, and chert in bands and nodules; the shales containing the remains of Polyzoa, and the limestones possessing the property of forming an inferior hydraulic cement. The upper part of the quarry exposes lighter coloured yellowish thin-bedded limestone with shale partings. Finally, in the hill-side above Tyn-yr-allt,† near Prestatyn, there are seen thin-bedded grey and brown limestones with thin shales, and chert-nodules and bands, some of the latter containing numerous casts of Encrinite stems and Foraminifera. These are succeeded by the Black Limestone subdivision.

Beds of the same age crop out in the Gop Hill near Newmarket, and, in consequence of the alternations of hard and flaggy limestones, give rise to regular terraces in the hill-side. Near the base of the hill on the west side there runs a black bituminous limestone, smelling strongly when struck; while to the north-west of Marian there is a hard white limestone with a saccharoid texture. A shaft on the north of Gop Hill has traversed a little thin-bedded sandstone with impressions of *Productus scabriculus* and *Streptorhynchus crenistria*,—possibly an attenuated representative of the thick sandstones that are interstratified with the limestone in South Flintshire. The above instances will serve to show that this part of the Carboniferous Limestone is very variable.

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* This is the "Upper Grey" subdivision of MR. MORTON.

† Spelt Tan-yr-allt on the one-inch Map.

The chert which is so abundant in these beds occurs either as nodules or in bands of four to six inches in thickness. The bands are frequently made up of the remains of Encrinites and Foraminifera, and thus differ from the overlying Chert Beds of Millstone Grit age, the mass of which is devoid of organic remains. The larger fossils also in these limestones are silicified; the carbonate of lime of the test, especially of the *Producti*, having been replaced by a form of chalcedony known as Beekite.* The great abundance of chert in the limestones of North Flintshire appears to compensate to some extent for the absence of the sandstones before alluded to as being intercalated in South Flintshire.

The absence of well-marked horizons in the limestone series makes it difficult to detect faults, though doubtless they are numerous, and consequently impossible to measure accurately the thickness of the subdivision. It may be roughly estimated that between the top of the Basement Beds and the base of the Black Limestone there are from 1,000 to 1,200 feet of strata.†

The following fossils have been observed in the upper part of this subdivision of the limestone at Tan-yr-allt, near Meliden, and at Tyn-yr-allt,‡ near Prestatyn:—

Spirifera glabra, Mart.
„ *pinguis*, Sow.
Terebratula sacculus, Mart.
Productus aculeatus, Mart.
Orthis resupinata, Mart.

And in the most southern of the quarries in the Coed-yr-Esgob, near Prestatyn, Mr. Morton has found:—

Cladodus mirabilis, Ag. (teeth of).
**Goniatites sphæricus*, Mart. (or ? *crenistria*, Phil.)
Orthis resupinata, Mart.
Productus semireticulatus, Mart.
Spirifera trigonalis, Mart., (var. *bisulcata*, Sow.)
„ *cuspidata*, Mart.
„ *glabra*, Mart.

At the Gop, near Newmarket, the following were collected by Mr. Morton:—

Euomphalus Dionysii, Goldf.
Athyris Royssii, L'Eveillé.
Chonetes papillionacea, Phil.
Productus aculeatus, Mart.
„ *cora*, D'Orb.
„ *giganteus*, Mart.
„ *semireticulatus*, Mart.
Spirifera trigonalis, Mart., (var. *bisulcata*, Sow.)
Lithostrotion Martini, Edw. & Haime.

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* *Geol. Mag.*, dec. 2, vol. vi. p. 334, 1879.

† The thickness assigned by Mr. Morton is 950 feet, *Proc. Liverpool Geol. Soc.*, vol. iv., p. 393.

‡ Spelt Tan-yr-allt on the one-inch map.

In a quarry at Axton, in the top of the subdivision, and immediately underneath the Black Limestone, MR. MORTON obtained the following species:—

*_Nautilus planotergatus_, M'Coy (=_Discites Lavellianus_, Koninck).
*_Orthoceras_, new sp.
Bellerophon, sp.
Euómphalus Dionysii, Goldf.
„ _pentangulatus_, Sow.
*_Macrocheilus imbricatus_, Sow.
Straparollus costellatus, M'Coy.
Natica ampliata, Phil.
„ _lirata_, Phil. (=_Narica lirata_).
*_Littorina_? new sp.
Loxonema sp.
*_Porcellia Puzo_, Koninck.
*_Ambonychia vetusta_, Sow.
Aviculopecten circularis, Koninck.
„ _fimbriatus_, Sow.
Edmondia unioniformis, Phil.
Sanguinolaria sp.
Athyris Royssii, L'Eveillé.
„ _planosulcata_, Phil.
„ sp.
*_Discina nitida_, Phil.
*_Orthis Keyserlingiana_, Koninck.
„ _resupinata_, Mart.
Productus cora, D'Orb.
*„ _aculeatus_, Mart.
„ _fimbriatus_, Sow.
„ _giganteus_, Mart.
*„ _latissimus_, Sow.
„ _longispinus_, Sow.
*„ _plicatilis_, Sow.
„ _punctatus_, Mart.
*„ _pustulosus_, Phil.
„ _semireticulatus_, Mart.
*„ _striatus_, Fischer.
Rhynchonella acuminata, Mart.
„ _pleurodon_, Phil.
*„ _pugnus_, Mart.
Spirifera trigonalis, Mar., (var. _bisulcata_, Sow.)
*„ _duplicicosta_, Phil.
„ _glabra_, Mart.
*„ _grandicostata_, M'Coy.
*„ _integricosta_, Phil.
„ _pinguis_, Sow.
„ _lineata_, Mart.
*„ _ovalis_, Phil.
„ _striata_, Mart.
Streptorhynchus crenistria, Phil.

Terebratula hastata, Sow.
Fenestella plebeia, M'Coy.
Griffithides seminifera, Phil.
**Amplexus coralloides*, Sow.
Syringspora geniculata, Phil.
Zaphrentis Griffithi, Edw. and Haime.

The species marked thus * have not been noticed elsewhere by MR. MORTON in North Wales. He states that the beds in which they occur are the "Upper Grey Limestone" of his papers. The specimens are for the most part remarkably perfect.

Near Golden Grove, at a short distance below the base of the Black Limestone, the following species were obtained:—

Aviculopecten papyraceus, Goldf.
Productus scabriculus, Mart.
Rhynchonella pleurodon, Phil.

(2.) *West of the Clwyd.*

The Carboniferous rocks, as previously stated, are thrown down to the west by the Vale of Clwyd fault. On the east side of the Vale, the beds plunge at a high angle of dip beneath the New Red Sandstone, but on the west emerge at a gentler inclination, forming an escarpment, which, much broken by faults, extends from Ruthin to Colwyn Bay. The portion of the escarpment which comes within this Quarter-Sheet includes the heights of Castell Cawr, Gorddyn mawr, Cefn-yr-ogof, and the Llysfaen hills. The range is continued, after a short interruption, in Bryn Eurian and the Little Orme's Head

The passage beds into the Conglomerate (or Lower Limestone Shales) are not clearly recognized in this part of the district. In the Valley of the Dulas, a very massive limestone appears to almost immediately overlie the Basement Beds, and forms an extremely bold mural escarpment. At Bryniau Cochion again, and in the lane above Penlwys (before alluded to, p. 6), limestone slightly impure, but not comparable to the passage beds of Moel Hiraddug, is seen to rest upon the Basement Beds. The hills named above are composed of the same beds that form the corresponding features in Flintshire, namely, the lower and middle parts of the grey and white limestone subdivision. Towards the north, where the upper cherty beds (Upper Grey Limestone of MR. MORTON) would be expected to succeed, the series is terminated by modern sea-cliffs, or by inland cliffs, perhaps in part of the same origin, against which Glacial Drift is banked up. The natural junction between the Limestone and the Millstone Grit indicated at Abergele is purely hypothetical, as will be shown subsequently.

A very pure white limestone has been quarried near Tan-y-gopa, and to the west of Siambr-Wen. The white limestone used for Bodelwyddan Church was obtained from these beds.

This neighbourhood was mapped by **Mr. Tiddeman**, by whom the following notes have been made:—

The Carboniferous Limestone, from near Abergele to the Dulas, forms an irregular belt of hills, about a mile, sometimes more sometines less, in width. At Siambr-Wen, south of Abergele, they are about a mile and a half from the coast, which they gradually approach in a sinuous curve until near Llandulas they are within 300 yards of it. The northern side is adorned by many fine rocky bluffs and mural scarps, some of them overlooking in dangerous proximity the picturesque modern castle of Gwrych.

The limestone is of the ordinary grey and white type, but sometimes darker towards the base, as at the southern scarp of Pen-y-corddyn-bach. At Tyddyn-Uchaf, south of Gwrych, the lower beds consist of grey limestones with earthy bands interbedded.

As a rule, over this area the dip is wonderfully constant in direction, chiefly to the N.N.W., but sometimes due north. The angle of dip is on the whole a little higher towards the base, where it averages 20°, whereas towards the northern side of the area it ranges from 10° to 15°.

Besides the faults already mentioned (p. 7) as shifting its base, we have the following:—

Siambr-Wen Fault.—There can be very little doubt of a large dislocation here. Not only are the lowest of the Basement Beds shifted from where they are visible in the Gele west of Pen-y-Graig to a point in the brook east of Pen-yr-allt (nearly a mile), but the base of the limestone is also shifted more than half a mile, from near Siambr-Wen to the back of the Pen-y-graig or Watch-Tower hill. The steep banks and crags of Castell Cawr from Siambr-Wen to Tan-y-gopa, overlooking the lower country, coincide with this direction, and make it probable that the fault continues in the same line. Beyond Tan-y-gopa we lose all rocks and features; but a very strong persistent spring at the south end of a drift mound near the coast may possibly indicate its further direction. This spring lies nearly due north of Tan-y-gopa.

R. H. T.

(3.) *The Black Limestone.*

This uppermost subdivision of the Carboniferous Limestone is locally known in the district as the "Aberdo Limestone," from the circumstance of certain beds in it possessing, in common with the Liassic limestones of Aberdo (or Aberthaw) in South Wales, the property of forming hydraulic cement. As, however, the same name is applied to any rock possessing the same properties, whatever its age, and as it is not advisable to give the name to both Carboniferous and Liassic limestone, it is proposed to distinguish the subdivision in this district as the Black Limestone.

In this area, and as far south as Holywell, the Black Limestone forms a very constant subdivision. It consists of evenly bedded black argillaceous limestones, in beds of 6 to 12 inches in thickness, separated by thin shale partings. The limestone has an earthy texture and a conchoidal fracture, and when freshly broken is black or dark-brown, but soon becomes coated with a fine white or yellowish film composed of an insoluble residue, probably of silica and alumina. Chert-nodules do not occur in limestone of this type, though they are abundant in the bands of limestone of crystalline texture which are occasionally interbedded in the series. The diffusion of the silica through the rock, in preference to its segregation into nodules after its usual habit, seems to be connected with the presence of a large proportion of argillaceous matter, a connection which is observable in other areas also.

Under the influence of weather the Black Limestone breaks up into blocks with clean-cut flat faces and sharp straight edges; with further exposure the angles of these blocks shell off, leaving a core of a very regular oval form, which subsequently becomes reduced in size by the peeling off of successive coats. The thin regular bedding, the sharply-cut joints, dark colour, and conchoidal fracture of these beds render them distinguishable at a glance from the ordinary type of limestone.

Several quarries have been opened in the Black Limestone in the hill-side above Prestatyn; one of the largest, by the side of the zigzag road leading to Gwaenysgor, is in a small outlier thrown in by a fault with a westerly down-throw. North-east of this, and at the foot of the hill, the beds roll over in a sharp faulted anticlinal, the axis of which runs towards Nant-y-mwyn. Near this mine the upper part of the series, consisting of shaly limestone and black splintery shales with *Aviculopecten*, is exposed in a dingle, the base of the Chert Beds (Millstone Grit) running along the road close above. The same beds apparently come to the surface near Terfyn, where an old quarry shows chert resting on dark limestone. A mining level passing below the high road a few yards west of this point was driven for some two or three hundred yards in these beds. From this highly faulted neighbourhood the Black Limestone may be traced without difficulty by Golden Grove and Axton to Llanasa. (Quarter-Sheet 79, N.E.)

On the west side of the Prestatyn fault the Black Limestone outcrop is shifted to the south of Meliden, a distance of about a mile and a quarter. (*See* Map in the Plate.) Its junction with the grey limestone can be traced along the hill-side to the railway, and through the northern workings of the Talargoch lead mine, the dip being to the north and north-east at an angle of 35° to 45°, except close to the Prestatyn fault, where the beds are locally tilted to the north-west. There are three quarries in the locality, showing beds similar to those at Prestatyn as described above. This is the most westerly exposure of the Black Limestone known. In and to the west of the Vale of Clwyd this subdivision has not been recognized, and is probably absent.

The stone from the quarries at Prestatyn has been tested for the property of forming hydraulic cement, but was found to be too "slaty." The principal sources of the so-called "Aberdo limestone" are at Afon Goch and near Holywell. (Quarter-Sheet 79, S.E.)

In addition to their marked lithological characters, the Black Limestones possess a peculiar assemblage of fossils. The *Posidonomya Becheri* occurs abundantly in the quarries in this district, though it is rare or unknown in the grey and white limestones, and in other parts of Flintshire. It is interesting to note that the upper beds of the Carboniferous Limestone of the Isle of Man are thin-bedded and black, and contain this fossil so abundantly as to have gained the name of "Posidonia Schists."* *Aviculopecten papyraceus* and Polyzoa are also abundant, and fossil ferns have been found to be plentiful near Gwaenysgor. The quarry in which the ferns occur is near the farm-house called Teilia, and is 600 yards north-east of Gwaenysgor church. The following beds are seen:—

	ft.
Thin-bedded black limestone and shale - -	10
Thick-bedded dark limestone, very irregularly split up by shale - - - - -	9
Sandy calcareous flags, with *Aviculopecten papyraceus*, *Goniatites bilinguis*, and abundant plant-remains -	6+

Specimens of the under-mentioned have been obtained from this quarry† :—

Staphylopteris.
Sphenopteris Honinghausii (?), Brong.
,, *affinis*, Lindley.
,, *artemisifolia*, Sternb.
,, *linearis*, Sternb.
,, *stricta*, Brong. (?).
,, *trichomanoides*, Brong.
,, *crithmifolia*, Lindley.
Adiantites Lindsæiformis, Salt.
Calamites pachyderma, Brong. (or *nodosus*, a coarse variety).
Hymenophyllites furcata, Göpp.
,, *dissecta* (?) Göpp.

Zaphrentis (? small sp.)
Sedgwickia (?) fragments.
Aviculopecten papyraceus, Goldf.
Posidonomya Gibsoni, Brown.
,, *Becheri*, Goldf.
Goniatites bilinguis, Salt.
Orthoceras (fragments).
Coprolite of fish (? *Megalichthys*).

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* Cumming's Geology of the Isle of Man.

† Some of these were first observed by the late MR. J. B. SHONE, to whom I had pointed out the quarry. MR. SHONE'S collection is now in the Museum of the Chester Society of Natural Science. The specimens were named by MR. R. ETHERIDGE.

In the same neighbourhood were obtained a tooth of *Cladodus*, *Ctenodonta*, and fragments of *Fenestella*. The last-named occurs in remarkable abundance in the Black Limestone on Halkin Mountain. (Quarter-Sheet 79, S.E.),—a locality from which extensive collections have been made by Mr. Shrubsole.*

As the Moel Hiraddug plant-beds (Lower Limestone Shales) form a passage from the Limestone into the Basement Beds, so these Black Limestones form a passage up into the Chert Beds or Millstone Grit. Moreover, as the Millstone Grit changes its character southwards, and passes horizontally from a chert into a sandstone, and finally into a conglomerate, so the Black Limestones give place to passage beds consisting of interstratified sandy limestones, calcareous sandstones, and pebbly sandstones. The series, viewed as passage beds between the limestone and Millstone Grit, may be compared with the beds that fill a corresponding position in Derbyshire and the northern counties, though it is clear, from the rapidity of the change in the same set of beds in Flintshire alone, that any precise correlation with distant parts of England is not to be attempted.

The thickness of this sub-division probably rather exceeds 200 feet in this district, but it thins away southwards, and is overlapped near Holywell (Quarter-Sheet 79, S.E.).

Millstone Grit.

The Chert Beds

There is in scarcely any part of this country a more remarkable development of chert than that which overlies the Carboniferous Limestone in North Flintshire. From the sea near Gronant it runs through Llanasa, Trelogan, Holywell, and Halkin Mountain, with a full thickness of probably not less than 350 feet,† and consisting, with the exception of thin shaly partings and a few shale-bands, of almost pure silica. Unlike the bands and nodules of chert in the limestone, this chert is probably a silicious sediment of extreme fineness; for not only is it well stratified, and evenly laminated, but, by a gradual lithological change, it passes horizontally into a fine-grained quartzose sandstone with bands of chert, and finally into a quartz grit with quartz pebbles, in which chert-bands are quite subordinate. This change commences near Holywell, and is completed in the neighbourhood of Llanarmon and Hope Mountain. It would seem to indicate that the source of supply of sediment lay to the south, as the finest material would be carried farthest. The corresponding change that takes place in the top beds of the limestone series has been already referred to.

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* *Quart. Journ. Geol. Soc.*, vol. xxxvii. p. 178, 1881.

† I was informed by Mr. Leigh Howell that chert extended from the surface to a depth of more than 175 yards, measured vertically, at the old engine-shaft of the Trelogan Mine. Mr. Morton however estimates the thickness in the present Quarter-Sheet at 250 feet, on the evidence of the shaft of the Talacre and Gronant Mine, which, as he was informed, reached the base of the Chert at 312 feet from the surface. *Proc. Liverpool Geol. Soc.*, vol. v, p. 402.

The lower beds of the Chert are exposed above the old Nant-y-mwyn mine. They are generally yellow or white, and occasionally contain thin bands of encrinital chert, honey-combed with cavities left by the decaying out of fragments of the stems. Numerous pieces of such bands may be picked out of some old mining hillocks above Terfyn, and near the Volcnant Telegraph Station. The encrinital chert has probably resulted from the silicification of a thin band of limestone, interstratified in the sedimentary chert. Bands of limestone of a few inches in thickness occur near Trelogan (Quarter-Sheet 79, N.E.)

The Chert Beds are shown as underlying the drift-covered area of Nant to the north of the anticlinal fault previously referred to Their presence here, which had been inferred from the dip of Black Limestone, was proved by a section opened by the great flood of August 1879, when a watercourse was cut down through the Drift, and exposed chert dipping to the north-north-west at 30°; the beds were of the black banded type.

Inland these beds are rarely well seen, in consequence of the great accumulation of chert-splinters, but they were proved about 400 yards north-east of Golden Grove in a trial shaft, and were found to contain bands of hard white fine-grained sandstone.

The higher beds of the Chert are generally black, thin-bedded, with partings of hard and brittle laminated shales. They are best seen in a quarry at Pentre near Gronant, where they are chipped into blocks for use in the Staffordshire Potteries.* The beds in this quarry show a peculiarity that is common in the Chert Series. Some of the bands are bent into rather sharp folds, which do not affect the over- or under-lying beds at a few feet distance. The folds would appear therefore to have been formed contemporaneously with the beds, or may be a form of current-bedding. There are also concretionary structures in the chert, and the quarry is traversed by a mineral vein containing black oxide of manganese. It may be noticed also that each band is made up of a central part of glassy chert, which passes both upwards and downwards into a fine-grained sandstone, so firmly cemented by silica as to possess the properties of a chert, but in which the individual sand-grains are distinctly visible. The one form seems to be a modification of the other by the same aqueous action by which it is believed the greater part of the Chert Beds have acquired their existing lithological character.

The workings of the Talacre Mine are principally in the Chert Beds. The vein is filled with calc-spar, and a great deposit of loose white sand, derived from the decomposition of a silicio-calcareous vein-stuff that is common in these beds. The ore is principally Zinc blende.

With the exception of the encrinital bands mentioned above, fossils are very rare. A specimen of chert, containing a portion of a stem of *Conularia quadrisulcata,* and probably from this part of the series, was shown to me by MR. J. B. SHONE. Southwards plant-remains are not uncommon.

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* **The black chert, dressed into cubes for sale, fetches about 15s. a ton. It is less valuable than the lighter coloured chert of Trelogan and Halkin.**

LOWER COAL MEASURES.

(1.) *East Side. The Holywell Shales and Gwespyr Sandstone.*

The Chert Beds pass upwards into a series of laminated shales, silicious and hard near the base, and ringing when struck, but becoming more argillaceous and softer above. They may be traced from Kelston Farm by the Engine House at the Talacre Mine to the Pentre chert quarry, and thence northwards by Gronant. Between Kelston Farm and the Talacre Dingle they appear to be cut off by the continuation of the Axton fault, on the east side of which the shales and sandstones of Gwespyr are introduced. Near Holywell, where they have received the name of the Holywell Shales, these beds contain bands of black impure limestone, resembling the Black Limestone, but of better quality for cement making, and characterised by the fossils *Posidonomya Gibsoni, Aviculbpecten papyraceus; Goniatites, Bellerophon,* and the plants *Sigillaria* and *Lepidodendron.** No cement stones or fossils have been observed in the small patches of shales included in this Quarter-Sheet, probably from want of suitable exposures.

The beds which are thrown down on the east by the Axton fault, as mentioned, are exposed in the Talacre Dingle; they consist of thick black shales with gannister sandstone, and are said to contain a thin seam of coal near the east end of the Talacre mine. They are underlain at a short distance to the east by the massive sandstones which are worked in the Gwespyr quarries, and which run through Flintshire at the base of the Middle Coal Measures in a position corresponding to that of the Gannister or Lower Coal-measure sandstones of Lancashire. The beds dip from Gwespyr westwards and towards the Chert, thus proving the existence of a fault in the place indicated.

(2.) *Vale of Clwyd.*

A narrow strip of these newer Carboniferous rocks is shown on the map as running from Prestatyn by Meliden and Dyserth up the east side of the Vale of Clwyd, and separating the Bunter Sandstone from the older Carboniferous Limestone and Wenlock Shale. The beds are nowhere exposed at the surface in consequence of the thickness of Drift, but have been met with in the mining operations at Talargoch and Dyserth. (*See* Map in the Plate.) The three principal veins of the Talargoch Mine run about south-west to north-east, and pass from the White Limestone through the Black Limestone. They are then lost to view in a great body of black shales with thin sandstones and coal-seams, which, succeeding immediately to the Black Limestone without the intervention of the Chert Beds, must clearly be introduced by a large fault. The position of this fault was proved in the Mostyn Shaft (about 100 yards south of Meliden church), at a depth of 190 yards; and in 1878 I observed the following section close to the shaft in a cross-cut from the South Joint at 180 yards depth.

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* MR. A. O. WALKER. *Proc. Chester Soc. Nat. Sc.*, No. 2. p. 9. 1878.

	ft.	ins.
Metal (or shale) -	10	0
COAL - - - -	0	5
Splintery metal -	1	2
COAL - - -	0	3
Metal - - -	2	0
	13	10

The metal (or shale) contained numerous Calamite stems and other plant-remains, and traces of small bivalves. The beds dipped to the north-north-west at 50°, and were found, in a continuation of the 180-yard level in the Talargoch Vein, to extend for 150 yards without any change. The same fault was met with in the other levels, both in the Talargoch Vein and South Joint, and its direction was ascertained to be about W. 10° S. to E. 10° N.; the hade being 1 in 1 (or 45°), the lower workings of the mine (to 330 yards depth) have of course been carried many yards further to the north-east than the upper before meeting the shale. (*See* Plate, Section No. 1.) It may be mentioned here that though no Chert *in situ* has been found in any part of the mine, fragments of this rock occur abundantly in the veins at the north-east end. The veins would, therefore, appear to have been formed and filled in before the cutting out of the Chert Beds by the fault described above. It is probable that the Chert Beds were much thinner here than near Gronant, for in other parts of the Vale of Clwyd they are known to have thinned out completely.

Three trials have been made to reach the rock between Talargoch and Prestatyn, but were all abandoned before penetrating the great depth of Drift (p. 29). A borehole by the side of the railway near Prestatyn (p. 27) is believed to have entered beds of late Carboniferous age, perhaps Middle Coal Measures.

The Lower Coal Measures, as shown on the Map, extend from near Meliden southwards by Dyserth in a narrow strip bounded on the west by Bunter Sandstone, and on the east by a great fault which throws them against Carboniferous Limestone, Basement Beds, and Wenlock Shale successively. The existence of the beds here is proved by the following evidence. The abrupt termination of the limestone and Silurian rocks is highly suggestive of a great line of fault introducing a softer rock under the Drift of the low ground; at Dyserth particularly the change of ground is very abrupt, the limestone ending in a little cliff, over which the stream precipitates itself in a picturesque gorge.* No rock is visible on the west side of the limestone feature, but the presumption that it marks a great line of fault is confirmed by the result of mining operations.

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* The village owes its name of Dyserth, signifying "A rushing of waters," to this fall.

In the Talargoch Mine the limestone is found to sweep round from a north-north-easterly dip at Tan-yr-allt to north-north-west under Meliden, and north-west under Graig-fawr. In accordance with these dips the Black Limestone should strike round the White Limestone, fringing it on its north-west side. But this has not been found to be the case. In sinking Walker's Shaft (on the west side of the high road about 700 yards north of Dyserth Hall) the following beds were met with:—

	Feet.
Glacial Drift (for details see p. 29) -	171
Hard blue limestone - - -	51
Shale - - - - -	168
White limestone - - - -	378+
	768

The hard blue limestone 51 feet thick was found to be not only underlain by shale, but to have shale on both sides of it; and in a cross-cut eastwards to the 110-yard level in the Talargoch Vein the shale was found to contain a thin seam of coal. As there is no coal or shale of this description in the Black Limestone series, these beds must be referred to the same age as those at the north end of the mine, and the hard blue limestone 51 feet thick, would appear (if limestone at all) to be merely a wedge-shaped mass dropped in along a line of great disturbance. The dip being very high the apparent thickness is much increased in a vertical sinking.

Further to the south along the same line the shale appears in the Talargoch Vein, forming the "hanging" or down-throw side of the vein in the 140-yard level at a point 50 yards north of the cross-roads. It occupies the level for a distance of nearly 40 yards, dipping north-west at 45° to 90°, and often completely shattered. It is dark or pale blue, laminated and micaceous, and quite unlike any of the shales occasionally found in the limestone. The limestone against which the shale is thrown is a hard massive rock, so much altered that the bedding is indistinguishable; there is no Black Limestone. The same shale, as I was informed, was again encountered in the south end of the 180-yard level in the Talargoch Vein, and sulphuretted hydrogen was given off so copiously as to affect the eyes of the miners.

The various points at which this shale has been encountered range themselves in a line running nearly north and south, and pointing to the neighbourhood of Dyserth, where, as before mentioned, there are surface indications of a great line of fault. Two trials for lead have been made here (see Plate) on the north and south sides respectively of the Waterfall.* The former, known as the Dyserth Mine, was sunk in limestone about 100 yards east of Dyserth church; drivings from the shaft westwards at a depth of 40 yards encountered a vein running between the limestone and a black shale of coal measure type, and filled with mundic (iron pyrites) in a stalagtitic form. The second trial, south of the waterfall, and known as the Ash Tree Shaft, was sunk to a depth of 80 yards; the westerly drivings having encountered a a great body of black shale, the mine was abandoned.

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* For the information concerning these I was indebted to MR. WILLIAM EVANS, who was in charge of the works.

From Dyserth southwards for some distance the line of fault is concealed under a thick covering of Drift; but there can be little doubt, from the form of the ground, that it runs near the foot of Moel Hiraddug and Cwm Mountain, cutting off the limestone and Wenlock Shale of these hills on the strike. It then falls into the line of the great fault which runs up the east side of the Vale of Clwyd, and throws down the top beds of the limestone or shales and sandstones of still later Carboniferous age against the Silurian rocks. The existence of numerous fragments of sandstone in the soil south of Fron-y-cwm provides the evidence on which the southern extension of the narrow strip of Lower Coal-measures to this point is assumed.

From what has been said above it will be seen that the information concerning the measures lying at the foot of the Silurian and Limestone hills is exceedingly scanty. In two cases only have explorations of any extent been made. The first, driven for 150 yards into the shale at the north end of the Talargoch Mine, has been already alluded to (p. 21); a second was driven from the Walker's shaft at a depth of 180 yards in a north-north-westerly direction. In 1878 I had an opportunity of exploring this old cross-cut with MR. LEAN (Captain of the Mine). It appeared to have been driven along a small fault running about N. 45°–60° W. with a down-throw to the west. For a few yards it contained greasy black shale or black limestone with white spar and zinc blende; at 140 yards from the shaft I observed on the north-east side brown cherty sandstone and shales dipping north-north-west. The foulness of the air rendered further investigation impossible. The probable succession of these beds by the Middle Coal Measures under the Bunter Sandstone in the direction of Rhyl will be discussed subsequently.

The following notes on the upper Carboniferous rocks of other parts of the Vale of Clwyd are by MR. TIDDEMAN.

In the old edition of the Geological Survey Map it was assumed that Triassic Sandstone filled the Valley of the Clwyd from the eastern to the western hill, and ranged round the northern side of the Carboniferous Limestone hills by Abergele, Gwrych, and Llandulas,—covering up, in fact, all the low ground. On re-surveying the ground about St. Asaph in 1879 I found that this was not strictly in accordance with the facts. An old quarry, well grassed-over, in Carboniferous sandstones, near St. Asaph, which had previously been overlooked, shed a new light upon the subject; and I also obtained additional information from a fresh digging, which was to be seen from the right bank of the Elwy above Pont-yr-allt-goch at an easterly elbow of the stream. Here there were pinkish purple and yellow Carboniferous sandstones and shales dipping N.N.E. at 15°.

A well-section at Maes-Elwy made, and particulars furnished, by **Major Birch**, gave the following section* :—

		Ft.	Ins.
Drift	Clay	54	0
	Clay with boulders	0	10
	Red laminated marl	5	0
Carboniferous Rocks	Clay, red and mottled	66	0
	Red sand, passing down into sandstone.		

The well-section at Llanerch,* on the other side of the hill or rather elevated plain between the Clwyd and the Elwy, gave the following particulars:—

		Ft.	Ins.
Drift	Clay	37	6
	Sand	12 to 9	0
Triassic	Red sandstone	36	0

A north and south fault brings the Trias against the Carboniferous Limestone at Denbigh, and the same line continued probably runs between these two sections, bringing down Triassic Sandstone on the east, and leaving the country to the west in Carboniferous rocks. This coincides with the position of the old quarries at Ysgubor-y-coed, near St. Asaph. They are on land formerly belonging to the Ecclesiastical Commissioners, and I was much struck by the resemblance of some of the building stones used in the Cathedral and also in Rhuddlan Castle to the material existing in these quarries. It was previously supposed that these stones had been brought from the Point of Ayr, but it hardly need be necessary now to search so far for their origin.

The old quarries on the Ysgubor-y-coed Farm are close to the Clwyd, left bank, south-east of St. Asaph. By digging I unearthed the following section at the west side of the workings:—

	Ft.	Ins.
Surface soil, working down into coloured clays	2	0
Clayey micaceous purple grey measures, coloured dark red in patches, and with minute nodules of hæmatite	4	0
Purple greyish and greenish white clays	3	6

These were dipping S. 15 W. at 10°.

Of course this was only a limited section, and a much larger exploration would be necessary to get down to the beds for which the quarries were worked.

I have called attention to these beds, although beyond the area of the present Quarter-Sheet, because they show that it is not only unnecessary but unsafe to assume that all the low ground up to the Limestone and Silurian hills is occupied by the Triassic Sandstones, as was formerly supposed.†

Taking this into consideration, I have represented the low ground from the Siambr-wen Fault to Llandulas as belonging to the Carboniferous Limestone, though no rocks are visible. Carboniferous Sandstones and Shales similar to those about St. Asaph may come on about Abergele, as shown on the Map, but of this there is no proof.

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* This well-section was given to me by **Prof. T. McK. Hughes**.

† These views were accepted by **Sir Andrew Ramsay** in the second edition of his Geology of North Wales. *Mem. Geol. Survey*, vol. iii. 1881.

R. H. T.

It was stated that the continuation of one of the faults seen in the limestone to the south had been found under the Drift near Abergele, with lumps of lead in it. This would appear to indicate that the rock is more probably Carboniferous than Triassic. The reasons for believing it to belong to the Lower Coal-Measures rather than to the Millstone Grit are given on the next page.

TRIAS OR NEW RED SANDSTONE (BUNTER).

Owing to the thickness of the Drift there is no exposure of the Bunter Sandstone in any part of this Quarter-Sheet, the nearest known section being near St. Asaph in the banks of the Clwyd. It has, however, been proved in borings at several points. The most important of these was made at the Foryd, near Rhyl, by MR. JOSEPH HOWELL, during the years 1860–61, in search of coal, under a license from the Commissioners of Woods, &c. The details of the strata passed through are as follows:—*

		Ft.	Ins.
Post-glacial and Recent, 58 feet 4 inches.	Clay - - - - -	2	0
	Sand - - - -	19	0
	Gravel - - - -	4	0
	Mud and clay - - -	16	6
	Turf - - - -	0	6
	Blue clay - -	10	4
	Turf - - -	1	6
	Blue clay - - -	1	0
	Gravel - -	3	6
Glacial, 39 feet 8 inches.	Red clay - - -	9	8
	Red sand - - -	1	0
	Dark sand - - -	6	0
	Red sand - -	1	0
	Sand and gravel - -	7	6
	Red clay - - - -	8	6
	Sand - . - -	4	0
	Clay and gravel - - -	2	0
New Red Sandstone, 499 feet.	Red sandstone - - -	93	0
	Metal (shale) - - -	0	6
	Red sandstone -	1	0
	Red metal - - -	2	0
	Red sandstone - -	33	10
	Red shale - - -	3	0
	Red sandstone - - -	10	10
	Red metal - -	0	6
	Rock - - - -	2	0
	Red metal - - -	1	6
	Red sandstone - -	5	6
	White sandstone with black shades - - -	1	2
	Red sandstone - -	89	8
	Red metal - - -	0	8
	Red sandstone - -	246	0
	White and red rock - -	7	10

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* This section was given to me by MR. LEIGH HOWELL.

		Ft.	Ins.
Coal Measures (?), 149 feet 5 inches.	Red marl	8	0
	White rock	2	0
	Red shale	45	1
	Red shale-rock	83	8
	White hard rock	3	6
	Red shale-rock	7	2
		746	5

It was the opinion of those who conducted this boring that the whole of the beds (below the Glacial Deposits) belonged to the Bunter Sandstone, but there is reason to doubt the correctness of this view. The Bunter Sandstone, wherever exposed in the Vale of Clwyd, consists of very soft red or mottled sandstone, with scarcely ever a pebble, or any variety in character: it is highly current-bedded, and remarkably free from shales. It will be observed that the red sandstone of the bore-hole corresponds to this description for a distance of 499 feet, but that the lower 149 feet 5 inches are described as marl, shale, and shale-rock,—terms which are quite inapplicable to any part of the Bunter Sandstone of the Vale of Clwyd. These lowest beds are believed to be of Carboniferous (and probably Coal Measure) age, for the the following reasons.

The series of purple shales and sandstones described above by Mr. Tiddeman, run up both sides of the Vale of Clwyd, resting conformably on the Carboniferous Limestone, but overlaid quite unconformably by the Bunter Sandstone. The sandstones are micaceous and flaggy or shaly, and of a deep purple colour with an occasional white band; while the shales are deep purple, grey, black, or variegated.* Near Llangynhafal the series contains a thin seam of coal. The beds, therefore, are undoubtedly of Carboniferous age, though bearing no resemblance to the Chert which lies next above the limestone on the east side of the Silurian range. They are, on the other hand, precisely similar to some purple strata which crop out at Maes Garmon near Mold, and which are attributable to Lower Coal Measures. It may be presumed then that the Bunter Sandstone of the Vale of Clwyd rests upon a foundation of Lower, and perhaps in part of Middle Coal Measures,—the Millstone Grit, as developed further east, having thinned out.†

From the description of the beds as given it seems extremely probable that the lowest 149 feet 5 inches of the bore-hole were in stained Coal Measures; and, in view of the steep north-westerly dip of the Lower Coal Measures at Talargoch, and of the fact that the limestone near Abergele is also dipping towards Rhyl, it seems more likely that the beds were of Middle than of Lower Coal Measure age.

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* The purple staining of beds of any age that immediately underlie the Trias is a well-known phenomenon.

† The evidence of the overlap of the Millstone Grit by the Lower Coal Measures will be discussed more fully in the Memoir on Quarter-Sheet 79, S.E.

Another bore-hole was put down by the side of the Chester and Holyhead Railway, 52 chains west of Prestatyn Station. The depth reached was 675 feet, the strata consisting (below the Glacial Deposits) of red sandstone, white sandstone, and red and white marls.* I was assured by a workman that a thin coal was met with in the boring, and a statement to the same effect was made before the Coal Commission in the year 1871.†

A third boring was made in Rhuddlan Marsh to a depth of 282 feet, and was stated to have been in Red Sandstone, with soft grey partings for the whole distance.*

It is stated also by M. MOISSENET that a fine red sandstone, presenting all the characters of the Bunter Sandstone, was found in one of the workings of the Talargoch Mine at a depth of 100 yards,‡ but no confirmation of this has been forthcoming.

The position of the boundaries of the Bunter Sandstone remains extremely uncertain. There is reason for believing that this formation is partly affected by the great faults, though probably not to the same extent as the Carboniferous rocks. The boundaries, however, which are shown on the Map are almost wholly conjectural. In age it probably represents the Lower Mottled Sandstone or lowest sub-division of the Bunter of Cheshire, a rock which it resembles in character and in occupying a position next above the Palæozoic strata.

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* This information was supplied by MR. GILDEROY.

† PROFESSOR HULL stated in evidence that "A boring has been carried on, but is now abandoned, about three miles east of Rhyl, in a position about half a mile north of the cliff of limestone, in which Coal Measures of some sort, and above the Mountain Limestone, were found." *Report of the Royal Coal Commission*, vol. ii., dec. 31, Q. 349.

‡ Mémoire sur le gisement du Minerai de plomb dans le Calcaire Carbonifère du Flintshire. *Annales des Mines*, ser. 5, tome xi. p. 351. Paris, 1857.

CHAPTER II.

SUPERFICIAL DEPOSITS.

GLACIAL BEDS AND PHYSICAL GEOGRAPHY.

On the edition of this Map for Superficial Geology, the distribution of the Boulder Clays, and that of the Sands and Gravels, is indicated by colour. The same tint, however, is used for Boulder Clay, whether over or under-lying sand and gravel of Glacial Age. All glacial sands and gravels also are represented by a single colour, though probably they are intercalated at different horizons in the Boulder Clay, no detailed classification applicable to the whole area having been found possible.

The whole of the low ground, and the flatter parts of the high ground, are overspread by these deposits. The bold hill-sides which enclose the Vale of Clwyd, skirt the coast near Abergele and Llandulas, and form the background of Colwyn Bay, are separated from the shore-line by a terrace of drift ranging from 150 to 200 feet above the sea at its landward margin, and sloping gently seawards. The rock-feature against which this Drift is banked is of sufficient steepness in places to be called an inland cliff. It runs from Gronant, south of Prestatyn, to Talargoch and Dyserth, and thence is continued in Moel Hiraddug and Cwm Mountain, up the east side of the Vale of Clwyd. Re-entering the Map near Abergele it includes the bold cliffs of Castell Cawr, Cefn-yr-ogof, and those again west of Llandulas to Penmaen (or Graig), the only point where it enters the sea. It is continued in the rock-slope which rises near Pwll-y-crochan and encloses Colwyn Bay on the south, and in the outlying rock-masses of Bryn Eurian and the Little Orme's Head. Mining operations, of which the details are given below, have proved that the rock-slope is continued beneath the Drift in the form of a buried cliff, and to such a depth that if the Drift were removed, this cliff would form the sea-shore of the present day. There can be little doubt that it marks the position of the sea-shore in pre-glacial times, and indicates the limit to which marine denudation had proceeded before the interruption caused by the temporary submergence of the Glacial Period. It may be mentioned here that the form of this pre-glacial coast was chiefly determined by the great faults shown on the Map, the effect of which has been in most cases to throw down rocks that would yield rapidly to denudation. The old coast-line, as far west as Llandulas, follows very closely the limits of the less yielding Silurian and Lower Carboniferous rocks.

One of the best sections of the Drift-deposits in the district was provided in the sinking of Walker's shaft at the Talargoch Mine. The shaft is situated at 200 yards distance from the limit of the

Drift, where the limestone rises in the cliff of Graig-fawr. The following beds were passed through:—*

		Ft.	Ins.
Glacial Beds	Soil	1	6
	Marl and clay	21	0
	Dry sand	10	6
	Quick sand	30	0
	Strong clay	6	0
	Gravel	24	0
	Gravelly clay, with water	30	0
	Sand and gravel	36	0
	Gravel, containing bones	12	0
		171	0
Carboniferous Rocks (p. 22)		597	0
		768	0

Dr. Buckland gives a section of the Talargoch Mine (the shaft not specified) as below:—†

		Feet.
	Vegetable mould	2
Glacial Beds	Clay	78
	Sand and gravel with pebbles of copper- and lead-ore, and horns, teeth, and bones	204
		284

Similar deposits were found in the shafts close up to the foot of Graig-fawr, showing that the steep limestone face of the hill is continued below the Drift as a buried cliff.

Another shaft, known as the East Talargoch Mine, was commenced about half-way between Meliden and Prestatyn, at a distance of 150 yards from the limestone slope of Carreg-y-frân; the Drift consisting of the following beds:—‡

		Feet.
Glacial Beds	Clay and stones	21
	Red clay	12
	Gravel	27
	Dark stiff clay	27
	Clean sand	36
	Stony clay and mud	48
	Moist sand (not bottomed)	33+
		204

Previously to this an attempt (also unsuccessful) had been made to reach the rock near Prestatyn at about 200 yards from the margin of the Drift near Tyn-yr-allt. The boring at Prestatyn (p. 27) entered the rock, as I was informed by a workman from memory, at about 70 feet depth.

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* This section was given me by Mr. Lean, Captain of the Talargoch Mine.

† Reliquiæ Diluvianæ, *London*, 1823, p. 178.

‡ This information was provided by Mr. Henry Ellis, of the Talacre and Gronant Mine.

At the Gronant Mine, at 160 feet above the sea-level, this section is given by DR. BUCKLAND:—*

	Feet.
Vegetable mould - - -	2
Clay, mixed with some sand and rolled stones - - -	78
Gravel beds, containing rolled pieces of lead of all sizes -	24
	104

A detailed section of the Foryd boring has already been given (p. 25), showing a thickness of 58 feet 4 inches of Post-glacial Deposits, and of 39 feet 8 inches of Glacial Drift, or a total distance to the rock-surface of 98 feet.

At Pen-y-cefndy, about a mile south of Rhyl, a well (now reserved to supplement the water-supply if necessary) was sunk to a depth of 63 feet in clay, sand, and gravel, without reaching the rock.

About one mile south of St. Asaph, between the Elwy and Clwyd, a shaft was sunk through irregular alternations of clay and gravel to a depth of 88 feet.*

The various depths below Ordnance Datum at which the rock-surface has been struck are given in the following table:—

	Height of surface above Ordnance Datum.	Depth of rock-surface below Ordnance Datum.
	Feet.	Feet.
Talargoch (Walker's shaft) -	130	41
East Talargoch - - -	180	24+
Prestatyn borehole - -	16	54 (about)
Foryd borehole - - -	18	80
Pen-y-cefndy - - -	45	18+

It appears from these figures that the rock-surface has a gentle seaward slope, as might have been expected.

The ancient line of cliff, against which these deposits are banked, as described above, is breached at Llandulas, Abergele, and Dyserth by steep-sided pre-glacial valleys.† Up each one of these there runs a tongue of Boulder Clay from the low-lying plain up on the higher ground, and spreading out over the uplands. In such cases the type of Boulder Clay seen on the coast is found to give way inland to a local till of Silurian débris.

In describing the character of the Drift, it will be convenient to deal with the whole of the deposits of each locality in succession, to avoid the necessity of correlating the clays or sands of one part with those of another, often an impossible task.

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* Reliquiæ Diluvianæ, *London*, 1823, p. 178.

† The probable origin of such gorges as those of the Dulas and the Elwy has been described by SIR ANDREW RAMSAY. Geology of North Wales (Memoirs of the Geological Survey), vol. iii., 2nd edition, p. 311.

In the low-lying area of the Vale of Clwyd, the newest member of the Drift is a tough, homogeneous, chocolate-coloured clay, with few boulders, consisting of grey granite, porphyries, limestone, quartz, and shell-fragments. The deposit is similar to and continuous with that which overspreads so large a part of South Lancashire and Cheshire, and, like it, is characterised by the large proportion of northern erratics. It is largely worked for bricks near Rhyl, Prestatyn, and Abergele.

The borings and sections of shafts given above show that it is interstratified with sand-beds, though these do not often appear at the surface. At Prestatyn there is a considerable area of soft red sand; and from Dyserth Hall a similar sand with interstratified beds of well rounded shingle extends through Bodryddan Park southwards (*see* Plate).

East of Rhuddlan the sand rises again through the Boulder Clay, in the form of a long low ridge or esker, while part of Rhuddlan itself is situated on a similar and parallel ridge. The southern end of this ridge has been cut into by the river, in the bank of which, near Plas newydd, may be seen—

	Feet.
Boulder Clay, thinning away northwards	10
Fine sand, about	20
Boulder Clay	2+
	32

It has been already stated that the Boulder Clay of the plain runs up the larger valleys so as to be continuous with that of the higher ground. This is especially well seen in the case of the valley at the foot of the Dyserth Castle rock (*see* Plate). The existing stream-course by which the water from Newmarket and Ffynnon Asaph descends from the hills, occupies a steep-sided limestone gorge which ends in the waterfall. But a little to the north a narrow but deep tongue of Boulder Clay runs up what appears to be the pre-glacial line of drainage separating the rock-hills of Crag Heilyn and Dyserth Castle. On attaining the high level of the limestone plateau this Boulder Clay spreads out in a great mass from one to two miles in breadth, and runs for some miles along the high ground to the south. A good section has been opened near the terminus of the Prestatyn and Dyserth branch railway, where the clay has been cut into for a depth of 18 feet without being penetrated, and is seen to be of a deep red colour, and similar to the drift of the plain. For a long distance southwards this tint continues to predominate; but finally, near Bryn glas, Pwll halog, Hendre-mynach, and to the south of these spots, passes into a yellow colour, while the northern boulders are replaced by fragments of Wenlock Shale from the neighbouring Moel Fammau range. The passage from the one Boulder Clay into the other is gradual, nor can it be said that one under- or overlies the other. They were, no doubt, formed contemporaneously, differing only in the source of supply of material. Northwards the red tint predominates in the tongues of Boulder Clay which run up the smaller depressions in the limestone plateau towards Gwaenysgor and round the Gop Hill to Axton, but is perhaps due to the clay being composed of the insoluble residue of limestone. A red tint often prevails in the soil of this rock.

Sand and gravel appears at intervals from beneath the clay at these high levels, as in the plain. At Henfryn the Newmarket brook has cut through red Boulder Clay and exposed sand with shell-fragments; and at Hendre-mynach there is a thickness of more than 25 feet of sand seen under a yellow more gravelly clay.

But in most cases the sand and gravel pushes up through the Boulder Clay in the form of steep mounds or ridges. A prominent example occurs near the Dyserth Railway terminus (*see* Plate). At a few yards only from the clay cutting before alluded to, a steep ridge of gravel rises boldly up, and runs up for about 300 yards in a north-east direction along the centre of the valley. The bedding of the gravel is arch-shaped, so as to be roughly parallel to the shape of the ground. The boulders consist of about 60 per cent of limestone (the larger blocks about six inches long), the remainder being chiefly Silurian. The coarse gravel is interstratified with bands of grit and sand with shell fragments, and the whole is cemented into irregular blocks by carbonate of lime.

Similar gravel-banks occupy the valley again a short distance to the north-east, but with an increase in the proportion of limestone boulders to 90 per cent. A sand-pit 500 yards south-south-west of the Gop Farm shows the superposition of the red Boulder Clay on the sand. The clay contains many scratched blocks of limestone about one foot long, a large boulder of volcanic ash from the Arenig mountains, and a few shell-fragments. The sand is fine, with gritty patches and veins of loam or clay, and also contains shell-fragments. The bedding of the sand is disturbed immediately under the clay.

The steep faces of all these banks are turned towards the west-south-west, and their longer axes are ranged towards the east-north-east. The general trend of all the drift-features on this plateau is in this direction.

An esker-like development of sand and gravel appears again at the margin of the Boulder Clay on the east side of Moel Hiraddug. The ridges consist of stratified sand and gravel with shell-fragments, but after running for 400 or 500 yards die out, leaving the clay in contact with the rock.

North of Gwaenysgor a long strip of sand and gravel is shown running over the Black Limestone and Chert outcrops towards Kelston. The line of separation between this deposit and the Boulder Clay is very indefinite. A gravelly character invades the clay, and chert-fragments increase in abundance northwards. Finally the gravelly clay passes into a sand and gravel deposit, which forms characteristic banks near Golden Grove. The same difficulty is met with in drawing a boundary between the sand and gravel and Boulder Clay about Axton, though the former preserves in the main its habit of rising into banks and hillocks. One of these occurs near Pant-glas, with an axis running about E. 10° S., and nearly parallel to the valley. A smaller one on the opposite of the valley, and 500 yards north-west of Ty-draw, runs from the hill side in a direction that would take it across the valley, though as a general rule the gravel-banks have their longer axes ranged in the direction of the valley in which they are situated.

Scattered over the country, over the drift-covered areas and the bare hill-tops alike, there occur large erratic blocks. Though scarce in the area now specially under consideration, they become exceedingly abundant further south, where they are found up to an altitude of more than 1,400 feet. A very large proportion of these has been derived from the felspathic volcanic series in the Bala Beds of the Snowdon and Arenig groups of mountains, and have therefore travelled in an east-north-easterly direction. One such, measuring 5 × 4 × 3 feet, occurs on Cwm Mountain at a height of about 830 feet above Ordnance Datum; another, of doubtful source, measuring 9 × 6 × 5 feet, lies in the bed of the stream near Hendre-bach (Hendre mynach on the one-inch map); a third, possibly from the Bala Beds, measuring 3 × 1½ × 1 feet, lies on the bank of the stream above Hendre fawr, the elevation of these being between 500 and 600 feet. A smaller boulder is imbedded in the side of the road at Pentre near Newmarket. Others occur in the Vale of Clwyd, and scattered over the Denbighshire hills to the west. These felspathic boulders are confined generally to the areas in which Drifts of western derivation occur.

Bones have been found in unusual quantity in the Drift of Talargoch, principally owing to the vast extent of gravel that was tunnelled through in different directions to get the gravel-ore. Buckland says, "the remains of ox and stag are found at present, and in 1815 a pair of stag's horns were discovered at 60 yards below the surface. . . . . . Horns, teeth, and bones are found in it [the gravel], at from 40 to 70 yards from the surface, and also at the bottom of the gravel, in immediate contact with the subjacent limestone rock."* Mr. Trimmer adds that two bones found in a bed of gravel at 63 yards from the surface, accompanied by marine shells, had been presented by Mr. Thos. Harrison, to the Caernarvon Museum. These were pronounced by Dr. Buckland to be the *astralagus* of a large, and the *humerus* of a small deer. At the time of Mr. Trimmer's visit the workings in the gravel had been discontinued, but the workmen "spoke of horns of deer, bones, shells, and timber, as having been found;" and the superintendent of the mine gave him "a specimen of *Purpura lapillus*, two of which had lately been found in sinking a shaft at the eastern end of the works. These happened to have been the only specimens of whole shells observed; but the miners described a bed of gravel near the western end as having been met with many years ago, abounding with 'Cockle-shells,' all in fragments."*

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* Reliquiæ Diluvianæ, p. 178.

One of the bones from Talargoch, now preserved in the Museum of the Chester Society of Natural Science, has been identified by PROF. W. BOYD DAWKINS as the left *ilium* of a bison.

It may be mentioned here also that pieces of bones belonging to rhinoceras, mammoth, reindeer, and horse have been recently discovered by DR. HICKS in the Ffynnon Beuno and Cae Gwyn Caves half a mile south of Tremeirchion (about two and a half miles south of the margin of this Quarter-Sheet.)† The bones are believed by DR. HICKS to have been introduced into the caves before the great submergence which led to the deposition of the high-level marine sands and gravels, and therefore also before the deposition of the great upper Boulder deposits of this area. In the case of the famous Cefn Cave also there was evidence of the ossiferous deposits being earlier than a part at least of the Glacial Deposits.‡ A full description of the Tremeirchion and Cefn caves is reserved for the Memoir on the Quarter-Sheet in which they occur (79 S.W.), but it will be seen, from what has been said above, that there is reason for believing the bones found in them to be of the same age as those found beneath the Drift at Talargoch.

Shell-fragments are of common occurrence in all the sands and gravels and in the red Boulder Clay, and may be found in any of the brick-pits about Rhyl, Abergele and Colwyn, *Cardium edule* being the most abundant. The specimens are always waterworn, and generally fragmentary.

On the west of the Clwyd the red Boulder Clay runs along the coast, forming the drift-terrace previously alluded to. The form of the terrace is especially well seen between Abergele and Llandulas. The clay as seen in the coast section and brick-pits near Abergele is a tough red clay with few boulders. Inland it sends long tongues up the valleys which separate the limestone hills, and mostly mark lines of fault. West of Llandulas the terrace becomes very narrow, and finally ends against the rock-promontory of Craig. On the east side of this promontory the following remarkable section is exposed in the sea-cliff.

Against the nearly vertical eastern face of the point is banked a stratified breccia, composed exclusively of sharply angular fragments of limestone, with a few blocks of 8 or 9 feet in length. The deposit at first sight resembles a talus, but the slope of the bedding is at too gentle an angle, namely from 10° to 20°, for this mode of production. The thickness of breccia seen in the cliff is about 80 feet, and it sinks eastwards to the level of the beach in about 150 yards. The breccia is overlain by 8 or 9 feet of stratified pebble gravel and sand, and this again by tough chocolate-coloured Boulder Clay, with numerous well-scratched boulders, which are in the proportions of about 80 per cent. of Silurian and 20 per cent. of limestone a short distance from the point and about 50 per cent. of each farther away.*

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* On the Diluvial or Northern Drift of the Eastern and Western Sides of the Cambrian Chain. By JOSHUA TRIMMER, Dublin, 1838, pp. 32, 33.

† On some recent researches in Bone Caves in North Wales. *Proc. Geol. Assoc.* vol. ix.; No. 1, p. 1; 1885.

‡ RAMSAY. Physical Geology and Geography of Great Britain. 5th Ed. p. 469; 1878.

From the beach the red clay rapidly mounts the less steep parts of the brow of limestone, and runs up the dip slopes to Llysfaen and Ty mawr, becoming more gravelly at the greater height. Taking advantage also of the deep gorge in the limestone occupied by the Dulas, it sends an arm inland as far Rhyd-y-foel (Foel-fach on the one-inch map), where it is succeeded abruptly by a grey and yellow drift composed exclusively of the local Silurian rock. The *foel* which gives its name to the locality is a conspicuous little hill projecting into the valley, and composed of a pebble-gravel of Wenlock Shale, banked up on a projecting shoulder of limestone. Southwards this gravel appears to pass into a more clayey drift composed of similar materials.

On the top of the point of Craig (or Penmaen) there are two small patches of Boulder Clay filling hollows in the limestone. In the westernmost of the two, the Drift reaches a thickness of 20 feet, as seen in section at the edge of the cliff, and rests upon a glaciated surface of rock (*see* p. 39).

Crossing the promontory of Craig into Colwyn Bay, we find the red Boulder Clay banked up against the limestone cliff without the intervention of any breccia or beds of gravel. Further west about old Colwyn and the dingle at Min-y-don it is concealed, or perhaps replaced, by a rudely stratified gravelly deposit made up entirely of Wenlock Shale fragments. This gravelly deposit is seen in the dingles to extend to some seven or eight hundred yards west of Colwyn Bay station, finally thinning out on the top of the red clay. The great ballast-pit at Colwyn Bay Station shows that this Silurian drift is in part contemporaneous with the red Boulder Clay, the two alternating or being mixed up together. The following sections prove this, and will serve to illustrate the rapid horizontal changes in the deposits.

Colwyn Bay Sand and Gravel Pit.

North end of the pit.

	Feet.
Silurian drift, in part pebbly and stratified (Wenlock Shale only)	10
Fine sand - - - - - - - - -	15+
	25

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* Mrs. T. McK. Hughes informs me that a skull of *Bos longifrons* and of *Cervus elaphus* (now preserved in the Cambrian Inn at Pensarn) are said to have been found at a depth of 18 feet in digging clay for making the railway embankment, and that there is also in the same Inn a fine pair of Red Deer antlers, which was washed out of the clay on the shore in a storm. There are barnacles (*Balanus*) on one of the highest tynes, showing that it had projected though the clay for some time. It is probable that these skulls and horns became embedded in the clay in consequence of a landslip. The undercliff about Llandulas Station consists almost entirely of slipped masses of Boulder Clay.

South-west side.

Silurian drift, as above	2—4
Red clay with few stones	9
Silurian pebble-gravel	20
Fine sand	—
	33

South side, towards the east end.

Silurian drift, gravelly, and mixed up with and containing masses of the red clay of the preceding section	20+

South-east corner.

Silurian drift, white loamy clay, with pockets or irregular bands of pebbly drift	6
Stratified loam and fine gravel	2—6
Red clay bent into sharp folds, and thinning out to the north	0—5
Silurian gravelly drift, with uneven surface	10+
	27

North-east corner.

Silurian drift, loam and gravel as above	6
Silurian gravel	20
Fine sand	1+
	34

Further along the beach westwards red clay with pockets of sand, and from 6 to 12 feet in thickness, is seen resting on fine sand with bands of pebble-gravel, the uppermost Silurian drift being exposed here and there at the top of the cliff as far as a dingle 400 yards north-west of Colwyn Bay Hotel. The bed of fine sand with pebbly bands is seen in this part of the bay to rest on the gently undulating surface of a mass of stiff blue clay full of intensely glaciated Silurian boulders, many of large size. The beds are much obscured by the slipping of the cliffs, but the following sections could be made out.

100 to 200 yards east of Colwyn Bay Hotel.

	Feet.
Red gritty clay with pockets of sand	6 to 12
Sand with pebble-gravel	12+

100 yards north-west of the Hotel.

Yellow loam	2
Silurian gravelly drift	4
Red clay, about	6 to 10
Sand	about 25
Blue clay, full of scratched Silurian boulders, seen in the fore-shore below the Hotel	

400 yards north-west of the Hotel.

Yellow loam (in part reddish), thinning from	4 to 1
Silurian gravelly drift do. do.	3 to 0
Red clay	8
Sand	10+

500 yards north-west of the Hotel.

Red clay, gritty	5
Sand	2
Tough red clay	4
Sand	14+

At the Bath House (700 yards north-west of the Hotel).

Red clay, gritty	6
Sand with bands of tough red clay	25
Blue clay, full of scratched Silurian boulders	4+

200 yards south of Aber-hod (150 yards north of the preceding section).

Red clay, gritty	6—9
Tough red clay, and sand in thin bands resting apparently unconformably on	4
Sand	18
Stiff blue clay as above	3+

North of this point the red gritty clay alone is seen in the low cliff which extends to the alluvium of Glan-y-mor. But on crossing to the outlying hill of Drift, which this alluvium insulates, we find a cliff rising to about 30 feet in its highest part, and composed of—

	Feet.
Red clay, sometimes nearly stoneless	4 to 10
Blue clay, with large intensely glaciated Silurian and limestone boulders	9+

The surface of the blue clay rises gently towards the centre of the hill, the red clay thinning out correspondingly. The junction between the two is usually sharp and conspicuous, but there is at times a passage, as though the materials had been mixed for a thickness of one or two feet. The Boulder Clay cliff which commences within the western side of the Map, shows a similar sequence with the intercalation here and there of 2 to 6 feet of sand and shingle with shell fragments between the two clays.

The limits of these various members of the Drift were found to be very obscure inland. The uppermost yellow loam and gravelly Silurian drift is confined to the neighbourhood of the cliff about Colwyn Bay Station and Hotel; and in the brick-pits along the Conway road the red clay is found resting on a sand that is doubtless continuous with that of the cliff; the sand with a trace of red clay over it is seen in an old pit near Pwll-y-crochan-isaf.

Towards Old Colwyn the gravelly Silurian drift, with every appearance of being mixed up with the red clay (as indicated in the ballast pit), extends further inland, and appears to merge into the blue clay-drift that runs up the valleys. On the south-west and south-east sides of Old Colwyn there is a considerable development of sand, possibly a continuation of the bed seen at Colwyn Bay Station. The sand is fine and stratified with a little gravel and a few thin seams of red clay, and forms small mounds or eskers. Towards the west the limit of the red clay runs from near the brick-pits mentioned above, by Bryn Eurian and Llys Eurian, towards Ty'n-rhiw.

The valleys which run southwards into the Silurian hills are occupied by a tough blue Till full of scratched Silurian boulders of local origin, with far-travelled blocks of felstone from the Snowdon range. This Till is exposed in many of the ravines to a depth of 30 to 50 feet, and runs up to a high level on the gentler slopes of the hills. The general direction of transport appears to have been about south-south-west to north-north-east, as indicated by the presence of the felstone boulders, and the appearance of limestone boulders in the local basement clay of the coast to the north-north-east of Bryn Eurian.

The various glacial beds seen in Colwyn Bay and the neighbourhood may be summarised as follows :—

Local drift; yellow loam and rudely stratified Silurian gravelly drift, resting upon or in part mixed up with—
Far-travelled red Boulder-Clay.
Fine sand with a little shingle.
Local drift; a very tough blue clay packed with scratched stones.

Glacial Striæ.

The following instances of striated rock surfaces have been observed during the Survey of this Quarter-sheet.

(1.) Limekiln, 50 yards south of Pen-yr-Allt, near Gwaenysgor; height above Ordnance Datum, 660 feet. The surface of the rock is protected by a little tough red Boulder Clay, and is well polished and marked with short scratches, fairly constant in the direction N. 5° W. The direction of flow was probably from southwards; the ground slopes towards the south-west.

(2.) Graig-fawr, near Dyserth (*see* Plate); height above Ordnance Datum, 160 feet. The striæ occur on a projecting shoulder of limestone at the foot of a very steep rocky slope facing west; they sweep round the shoulder horizontally. The direction of flow must have been from north to south, the projections of the rock being smoothed and striated on the sides facing north.

(3.) Moel Hiraddug, near Dyserth; height above Ordnance Datum, 750 feet. The striæ occur on a terrace of limestone on the east side of the hill, the ground sloping to the east-north-east; they are covered by a little gravelly Boulder Clay. Direction N.E.

(4.) *Cwm Mountain; height above Ordnance Datum, 990 feet. The striæ occur in a driftless area 200 yards to the east of the highest point of the hill, and may be exposed by removing the turf. They vary in direction from N.E. to E. 33° N.

(5.) Craig Cliff, near Llandulas Station; height above Ordnance Datum, about 70 feet:—

(a.) In a small hollow leading up to the air-shaft of the tunnel, and filled with drift. Direction N. 10° E.

(b.) On a nearly horizontal surface of limestone a few yards to the east of the hollow mentioned above. Direction N.E.

(6.) Craig Tunnel, near Llandulas Station; height above Ordnance Datum, 130 feet. The brow of limestone forming the roof of the east entrance of the tunnel is well glaciated in the direction N. 10° W.

(7.) Quarry on the south side of the high road above Llandulas Station; height above Ordnance Datum, about 270 feet. The striæ were exposed by the clearing away of about three feet of red Boulder Clay from a broad surface of limestone; they were long, and not perfectly straight, in a direction N. 30° E. The ground slopes to the north, towards the adjoining cliff.

(8.) †Cefn-yr-ogof, on the east side of the valley of the Dulas; height above Ordnance Datum, about 230 feet. Direction of the striæ N. 12° E.

The connection between the direction of the striæ and of the drift-transport is very noticeable along the Welsh border. The north-easterly trend of the striæ on Cwm Mountain, Moel Hiraddug, and the north coast is generally maintained by the striæ near Holywell, Mold, Minera, and Llangollen; and throughout these regions the transportal of the drift-materials has been towards the north-east or east. This Quarter-Sheet includes a considerable length of the irregular boundary which separates the local Welsh Drift from the west from the far-travelled northern Drift as previously described, and in the striæ of Graig-fawr, which are in the area of the latter, contains an interesting example of the corresponding change in the direction of the glaciation.

A further connection between the striæ and Drift is found in the fact that the glaciated surfaces always occur in conjunction with the Boulder Clays in preference to the stratified sands and gravels; and the Boulder Clays, alone of the drift deposits, show such evidence of the action of ice, as want of stratification, the

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* Pointed out to Mr. R. H. Tiddeman by Prof. T. McK. Hughes.

† Observed by Mr. R. H. Tiddeman.

presence of scratched stones, and the mechanical disturbance of the underlying beds. It seems reasonable, therefore, to attribute the striation of the rock-surface and the distribution of the Boulder Clays to the same agent, probably floating ice.

POST-GLACIAL BEDS.

Calcareous Tufa.

A large mass of this material overspreads the slopes above Felin Nant, near Prestatyn. It was formed by the overflow of a spring, by which the mill was formerly worked, but which has now been drained by the mining operations. The tufa consists of white amorphous carbonate of lime, encrusting twigs, snail-shells, and other fragments mixed with sand, and is sometimes hard enough to be dug out in blocks for ornamental rockeries. Another smaller patch occurs in the field between the railway and the farm Cefn-yr-ogof, three-quarters of a mile east of Llandulas.*

Peat and Alluvium.

These deposits occupy a large area, bordering the rivers Gele and Clwyd, and the sea-coast between Rhyl and Prestatyn. Near the estuary of Clwyd the upper layers consist of alternations of tidal silt and "slutch," overlying or alternating with sand, and, towards Prestatyn, of fresh-water marsh-clay and peat, occupying the sites of shallow meres enclosed by dunes and low banks of blown sand. Below these recent beds there occur several beds of peat ranging down to about 40 feet below Ordnance Datum. Our information concerning these is derived chiefly from the boreholes, which are described below.

The Foryd borehole (given in full on p. 25) commenced at 12 feet above Ordnance Datum, and reached the base of the alluvial deposits at 46 feet 4 inches below this datum, giving a total thickness of 58 feet 4 inches. The following beds were passed through:—

	Ft.	ins.	Ft.	ins.
Surface of ground	-		12	0 above Ordnance Datum.
Clay	2	0		
Sand	19	0		
Gravel	4	0		
Mud and clay	16	6		
Turf [peat]		6		
Blue clay	10	4		
Turf [peat]	1	6		
Blue clay	1	0		
Gravel	3	6		
	58	4	46	4 below ,, ,,

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* Larger deposits of calcareous tufa are found in two of the valleys near Caerwys, in Quarter-sheet 79 S.E.

Two boreholes were put down at the Rhyl Town Hall for the purpose of testing the ground. No. 1, on the south side, proved the following beds:—*

	Ft. ins.	Ft. ins.
Surface of ground - - -		20 0 above Ordnance Datum.
Made ground about	3 0	
Yellow sand, damp in places - -	6 7	
Blue clay, with traces of peat in places -	5 5	
Strong peat, dark at top, light and mottled below, with branches of trees and parts of trunks - -	3 0	
Strong blue clay - -	2 0+	
	20 0	0 0 ,, ,, ,,

Peat was also met with in the sewer in the Marsh Road, and is now exposed to view in the bottoms of the brick-pits in the marsh lying on the south side of the town. The section here shows three to four feet of blue clay with *Scrobicularia piperata*, resting on peat with large tree-trunks. The level of the top of the peat-bed is about nine feet above Ordnance Datum. Peat-beds may also be seen cropping out in the foreshore between Rhyl and Abergele, where they have been much bored into by *Pholas*.† MRS. T. McK. HUGHES remarks also that "in the marsh land bordered by the sand-dunes north of Prestatyn, at the edge of the water in some of the gutters, quantities of very large shells of *Scrobricularia piperata* are found sticking up in their original position. The valves are usually together, though the ligament has often perished, and the shells are much stained and encrusted with calcareous mud. It seems as if the stream had cut down to the bed in which they lived under former conditions of the district. On the shore side of the dunes there are patches of clay much bored into by *Pholas candida*. Pieces of blackened wood and hazel-nuts, some of the latter apparently gnawed by squirrels or some other small rodents, are found along the shore, and are probably washed out of patches of peat which are seen here and there."

The *Scrobicularia piperata* being a marine or estuarine shell, it would appear that the clays in which its occurrence has been noted above have been laid down by the tide, at a time when the sea had access to channels and low-lying hollows which are now enclosed by sand-hills or protected by artificial banks.

A section, similar to that at Rhyl, occurs at the north-west end of Colwyn Bay, where the low-lying alluvium of Morfa-Llandrillo abuts upon the shore at Rhos. The beds have been described by MR. H. F. HALL, as follows in brief*:—Two beds of peat occur about six feet apart, and six and twelve feet respectively below high-water mark. The upper bed is about one foot thick, and consists of peat with tree-roots, and traversed by branches and trunks. The roots penetrate an underlying blue clay, and the trunks lie in all directions as they fell; one was found to be fully 50 feet in length, and a stump *in situ* was three feet in diameter. This upper bed is underlain by six feet of blue clay with a few pebbles, below which occurs the second peat-bed similar to the first. The trees are believed to be oak and pine. The peat-beds were again met with in a well sunk for the new Rhos Abbey hotel, which proved the following section:—

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* This information was supplied by MR. A. BELL, C.E.

† MR. W. SHONE states that *Pholas* may be seen living in the peat-beds at low spring-tides.

	Feet.
Sandy gravel - - -	3
Solid blue clay - - -	15
Peat-bed, with trees, about -	1
Blue clay - - - -	4
Peat-bed, with trees - -	1
Fine clay mixed with sand -	3
	27

This strip of alluvium insulates the Boulder Clay hill on which Capel St. Trillo stands, and is continuous with the broad marsh that comes down from Llangwystenin. The marsh is in part below the level of high spring-tides, and is protected by an artificial bank and sluice. In the absence of such protection, and of the alluvial deposits that have raised the level of the land, there would probably be free communication by this valley between the sea and the river Conway, as has been suggested in a paper by Mr. C. R. HALL.† In this paper Mr. HALL refers to a tradition of the Welsh that the coast from Anglesea to Flintshire was formerly fringed by a fertile plain called "Morfa Rhianedd," which was destroyed by sea and land floods occurring coincidently in A.D. 331. The residence of Helig, the owner of these lands, was situated, according to tradition, on the shoal known as Llys Helig ab Glanawg, at a distance from Gogarth of nearly five miles, and from the Dwygyfylchi shore of two miles. In 1864 Mr. HALL, in company with the Rev. R. PARRY, visited the shoal at low tide, and found what he believed to be traces of the foundations of a house consisting of three wings enclosing a court-yard, and the remnant of the base of a round tower.

An epitaph in Abergele churchyard is popularly supposed to constitute further evidence of loss of land on this coast. The subjoined copy of the epitaph, and note upon it, are furnished by Mr. TIDDEMAN:—

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* Notice of Submerged Forests at Rhos, near Colwyn. *Proc. Liverpool Geol. Soc.*, sess. 7, p. 31, 1865–66.

† Some Conjectural Hints towards determining the Ancient Coast-line of North Wales, between the River Dee and the Island of Anglesea. *Geol. Mag.*, vol. ii. p. 78, and *Proc. Liverpool Geol. Soc.*, Sess. 6, p. 7, 1864.

Built into the wall of Abergele churchyard is a gravestone bearing the following inscription :—

"Yma mae'n gorwedd
Yn monwent Mihangel
Gŵr oedd a'i annedd
Dair milltir yn y gogledd."

which may thus be translated :—

"Here there reposes
In the churchyard of Michael
A man who had dwelling
Three miles to the northward."

The characters would lead one to suppose that it may date from the beginning of the 17th century, but unfortunately no date has been placed upon the stone. Tradition says that it is a copy of a much older stone. Close by in the wall is another stone with three letters on it, which is considered by some to be part of the original, but this has not been proved to be the case.

The site is now less than a mile from the sea. The obvious inference intended to be drawn from the wording of the inscription is that during the lifetime of the person here buried a great sacrifice of land to the ravages of the sea had occurred. Evidently the site alluded to was no longer dry land. Had it been, the name of the place would have been given, or it would not have been referred to in so mysterious a manner. Both the name of the man and of the place of his dwelling are suppressed in order to bring into prominence the fact of the latter having been three miles to the north. Well prepared as we may be to admit the destruction of the land by the sea, we must not, I think, lay too much stress upon this epitaph. It is quite possible that it may cover merely the grave of an unknown mariner who was washed ashore, and whose "dwelling" was wrecked at that distance from Abergele. Such semi-jocular epitaphs under like circumstances are not uncommon on our coasts.

R. H. T.

The evidence of the peat-beds described above seems to prove that the coast has lost considerably in level since the close of the Glacial Epoch. The level of the lowest marshes of the present day that are not liable to be overflowed by the tide (including those that are artificially protected) ranges from 12 to 15 feet above Ordnance Datum. The peat-beds of Rhos and of the brick-pits and bore-hole in Rhyl, which seem to be old forest-grown land-surfaces, occur at or but little above Ordance Datum, and seem to mark the last stages in the process of submergence, before the coast assumed its present level. The level of the ancient lands referred to in the Welsh tradition, if they ever existed, may be indicated by one of these beds. The position of the alleged foundations of the Llys Helig would indicate a loss of about 25 feet in level, supposing them to have been walls orginally built above the level of high-tide. Evidence of oscillations of level are found also on the Cheshire* and Lancasshire coasts.†

Blown Sand.

The line of dunes is narrow from Abergele to the Clwyd, and has to be artificially made up; but east of this river the sand spreads inland on to the gentle slopes of Boulder Clay south-east of Rhyl, and towards Prestatyn rises in dunes 40 or 50 feet above the sea, forming an ample protection to the broad marsh behind. The sand is carried along the shore from west to east by the prevailing winds and by the flood tides, a fact clearly indicated by the eastward trend of the river channels on entering the tidal region. Off Prestatyn the growth of sand-banks is being encouraged by intercepting the drift by lines of stakes and wattles. Further east the sand has been arranged by the wind in low ridges running from the north-west, and enclosing shallow marshy or peaty flats.

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* De Rance, Geology of the Country around Prescot (Geol. Survey Memoir), 3rd Edition, p. 31; *Proc. Liverpool Geol. Soc.*, Sess. 10, p. 37 (Potter); *Geol. Mag.*, vol. x. (De Rance and Mellard Reade).

† De Rance, Superficial Deposits of S.W. Lancashire (Geol. Survey Memoir).

CHAPTER III.

ECONOMIC GEOLOGY.

MINING.

The following ores have been worked in the Carboniferous rocks of this district.

Galena, in part argentiferous (sulphide of lead with silver).
Blende (sulphide of zinc).
Calamine or "Coke" (carbonate of zinc).
Hæmatite (oxide of iron).
Hæmatite with nickel and cobalt.
Hæmatite with copper.
Pyrolusite (dioxide or black oxide of manganese).

Galena, Blende, and Calamine are found only in the upper or middle beds of the Limestone and in the Chert beds (Millstone Grit). Hæmatite is generally confined to the lower beds of the Limestone and the Basement Beds. Manganese ore occurs in the Chert and in the Basement Beds.

LEAD AND ZINC ORES.

These ores are usually found in close connection in the same vein, the zinc ores and the argentiferous galena, however, being almost invariably confined to the east and west veins, while a non-argentiferous galena with minute traces of copper is found in the north and south cross-courses. In this part of Flintshire the veins do not so readily fall into the two systems as in the neighbourhood of Holywell and Mold, where the rule is well established. The Talargoch veins, for example, which are essentially of the east and west type in their contents, run nearly north-east and south-west.

Calamine, and more rarely "white lead" (carbonate of lead), are found in the shallower parts of the veins, and pass downwards into blende and galena respectively; they are probably formed by the weathering of these ores.

The silver occurs in the galena in proportions ranging up to 12 (or rarely 14) ounces per ton. It is extracted by the zinc process at Bagillt and Llanerch-y-mor, and is found to repay the cost when exceeding 3 ounces per ton.

The principal mines in this area are the Talargoch and the Talacre. There have also been trials made with partial success at Kelston, Golden Grove, Volcnant, Nant-y-mwyn, Gwaenysgor, Dyserth, and near Abergele.

Talargoch Lead Mine. (*See* Plate and Sections.)

This great mine is said to have been worked continuously from a very early period. THOMAS PENNANT states, "I am in possession of a little wedge five inches and a quarter long, presented to me by the late MR. SMEDLEY, of Bagillt Hall, discovered in working the deep fissures of Dalar Goch rock in the parish of Diserth in this county. This little instrument affords a proof of its antiquity by being almost incrusted with lead ore. It had probably lain in the course of some subterranean stream which had brought along with it leaden particles and deposited them in the iron."* It is believed that lead was mined in Flintshire during the Roman occupation,† and that this was one of the mines in operation at that period. But though the strings which run down the rocky sides of Graig-fawr would be among the first to attract attention, it seems hardly likely that the deep-seated veins which have yielded the bulk of the ore in modern times should have been reached through the thick water-bearing Drift which covers them. In this case, as in most others, there is little more than tradition as to the age of the first workings.

It has already been shown that the beds of limestone sweep round Graig-fawr, dipping to the north and north-west until they are cut off by the great Vale of Clwyd fault. The veins, having a general north-easterly direction, traverse the beds at an acute angle, so as to pass gradually from the massive white limestone of the south-west end of the mine into more thinly-bedded limestone, and finally through the Black Limestone series of the north-east end, where they are cut off by the shale as previously described (p. 21); but their direction so nearly coincides with the strike of the thin-bedded limestones that the vein-products are often found occupying the position of a bed between two highly inclined bedding-planes marked with slickenside.

The veins are three in number, and are known as Panton's Vein on the north-west, the Talargoch Vein in the centre, and the Cae-llys, Coetia-llys, or South Joint to the south-east. They are roughly parallel, and all hade or "underlie" to the north-west. The direction and hade of the Talargoch Vein at various points are as follows:—At the south-west end, N. 22° E., at 1 in 2; under the high road, N. 34° E.; near the office, N. 50° E., at 1 in 7; near the Methodist chapel and at the Mostyn shaft, N. 50° E., at 1 in 2; and at the north-east end, N. 50° E., at 1 in 5. The direction of the South Joint varies from about E. 8° N. in its southern part to E. 41° N. towards the north, the hade being about 1 in 3. It has been worked for a distance of about 200 yards southwards from the shale-fault which forms the northern boundary of the mine. Panton's Vein first appears a few yards north of Walker's shaft, and runs N. 30° E., curving to N. 50° E. on approaching the shale-fault. The Talargoch Vein alone runs the whole length of the mine, a distance of about 1,400 yards.

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* The History of the Parishes of Whiteford and Holywell, 1796, p. 122.

† "Near Norton [Cheshire] there have been many pieces or pigs of lead dug up of an oblong form: the upper part of some was thus inscribed. Imp. Vesp. vii. T. Imp. V. Coss. On others was this inscription. Imp. Domit. Aug. Ger. De. Ceang." *England Displayed*, vol. ii., p. 72.

A pig of lead, bearing an inscription which commences with the word Caesar, but of which the rest is obliterated, was found in Commonhall St., Chester, and is now preserved in the Museum of the Chester Archæological Society. Another, found near Hoole Lane in making the canal, bears the name Vespasian, and is now at Eaton Hall. Lead was used by the Romans, as is known by the discovery of the remains in Chester, for their funeral urns, and it is believed also for their salt-pans at Northwich, as well as for many other purposes.

In former days a large quantity of ore was obtained from the base of the Drift. It was found in large water-worn lumps distributed over the surface of the rock, and was obtained by driving galleries in various directions through the gravel, which had been drained of water by the pumping in the mine.* Ore found in this manner is known as Gravel or Round Ore; it commonly occurs near the outcrop of a productive vein, and forms a useful indication to the miner. It may be supposed that as the rock containing the vein perished and was washed away, the lumps of ore remained behind, owing to their higher specific gravity.†

The workings in the Talargoch vein have been carried to a depth of 360 yards from the surface at the north end, and in the South Joint and Panton's vein to about half this depth.‡ In 1881 a lode rich in blende, but with little lead, was being worked at the former depth in the Talargoch vein, while to the south pockets and "flats" connected with the same vein, at 220 yards depth were yielding large quantities of lead with little or no blende. The replacement of the lead by blende in the depth proved unfortunate for the mine. The shallower parts of the veins mentioned above may be considered exhausted. As shown in the accompanying section (Plate, Section No. 2) the white limestone of the south end yielded vast quantities of ore, while the Black Limestone also was highly productive, though in other mines it has generally been found to be barren.

At the south end of the mine the Talargoch vein splits up into and is intersected by numerous small strings from which a great quantity of ore has been raised. Some of them may be seen running up the sides of Graig-fawr and the rock on which Dyserth Castle stands. Their direction varies from E. 25° N. to about E. 50° N.; but one of the strongest, known as the China Rake, runs E. 10° S., intersecting and cutting off the others. It obtains its name from the fact of its being filled with a fine silicious vein-stuff, which has been used in the Staffordshire Potteries. The deposit in its unweathered state resembles granular quartz, but readily weathers into a loose pure white sand. It often contains lumps of calc-spar and galena, and is clearly a chemically formed vein-product, not to be confounded with the chert-breccia which is found in the veins at the north end of the mine (p. 21). Silicious vein-stuff is commonly found in the Flintshire veins, especially in the beds which lie next below the chert, but not often in such purity. From the China Rake the silica runs down towards the Clive shaft along a string from which it is occasionally raised at the present time.*

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* For an account of the bones found during these operations, *see* p. 33.

† Masses are said to have been found so large as to have yielded 80 tons of ore.—TRIMMER: On the Diluvial or Northern Drift of the Eastern and Western sides of the Cambrian Chain, p. 33.

‡ Plans and sections of the mine are deposited in the Home Office, Whitehall.

It may be mentioned here that a combustible pitch was found to issue from a fissure in the south end of the 180 yards level in the South Joint; and M. MOISSENET remarked a banded red and white deposit from the water in this level, consisting, as he believed, of alternate layers of sulphur and oxide of iron.†

In some of these strings Calamine, locally known as "Coke,"‡ was formerly worked, and one of the day-levels in Graig-fawr is still called the Coke Hole. This mineral used to be abundant near Holywell, where it has been worked since the year 1740.§ It was found in the shallow parts of the veins only.

The total production of galena from the Talargoch mine in the years 1845-84 inclusive amounted to 57,752 tons, yielding 43,821 tons of metallic lead (or about 75·8 per cent.), and an average of 9½ ounces of silver to the ton. The yield of blende in the years 1855-84 inclusive, was 49,810 tons.‖ The average yearly sale for the three years 1880-82 was stated to be 1,035 tons of lead, and 3,041 tons of blende, in the advertisements offering the mine for sale in the year 1883. But in the year 1883, though 2,910 tons of blende were raised, the production of lead fell to 391 tons, and in May 1884 the pumping was abandoned, and the mine allowed to fill with water up to the day-level. The operations are now confined to the redressing of the old rubbish heaps.

The Talacre Mine.

Two metalliferous veins, known as the Talacre or Spar Vein and the Joint-y-clawdd, respectively, run through the top beds of the Chert at Gronant. The Talacre Vein is a fault with a small down-throw to the south, and underlying therefore in this direction. It has been worked of late years principally at the east end, near the fault which throws the Chert against Lower Coal Measures. Westwards it has been followed as far as the Sycamore Shaft, near the Calvinistic Methodist Chapel, and is believed to run through some old surface-workings by the side of the road leading to Golden Grove. The direction of the vein at the east end is a little south of east, curving by the Engine Shaft to E. 10° N., and near these old workings to about E. 20° N. The Joint-y-clawdd is a vertical string running through the Pentre Chert quarry, which intersects the old workings, and thence along the edge of the plantation, passing 90 yards south of the Engine Shaft to the smithy, near which it is said to join the Talacre Vein. The old trenches along the joint are still open for about 250 yards, and provide the reason for the name (Clawd, *Angl.* ditch); they show the junction of the Chert with the overlying shales as before mentioned. The general direction of the Joint-y-clawdd is E. 20° N. A similar joint in the same beds, and bearing N. 40° E., has been worked open-cast by the side of the road near Kelston Farm.

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* MR. W. SMITH, Secretary of the late Company, states that the value of the white sand would be about 10s. per ton, but that there is no commercial demand for it.

† Mémoire sur le gisement du Minerai de plomb dans le Calcaire Carbonifère du Flintshire. *Annales des Mines*, ser. 5 tome xi. p. 351. Paris, 1857.

‡ There is some uncertainty as to the origin and spelling of this name. It may be derived from the friable and cinder-like appearance of the mineral. It must not be confounded with Cawk, a popular name for Barytes.

§ PENNANT remarks that though the uses of Calamine were known to the Romans, the knowledge of it in after ages was long lost. . . . . . . Our country abounds with it, but till within these 60 years we were so ignorant of the value as to mend our roads with it; which have of late years been turned up in a hundred places most successfully to recover the lost wealth." *History of Whiteford and Holywell.*

‖ Mineral Statistics of the United Kingdom, by R. HUNT.

The workings on these veins are all in the Chert Beds, which are of great thickness, the lowest level on the Talacre Vein being at 105 yards depth. At the time of my survey the mine was inactive, and the following description is taken from the paper by M. L. MOISSENET (*op. cit.*) The hade of the veins was 2 in 3 at the top, and 1 in 1 lower down. In the 30-yard level from the Engine Shaft going west, the lode was at first almost barren in a dull chert, but after joining another equally poor it acquired a width of six yards, and contained a mass of galena six feet thick. West of this junction the vein spread into three or four strings, the northern one showing chert in the hanging, shale in the hading side. In the 48-yard level the vein was several yards broad, with chert in the hanging, and "gravel" in the hading; a cross-cut to the Engine Shaft ran for 30 yards in sand. Round ore (gravel ore) occurred in the gravel at the contact of the rock. The mine yielded galena, calamine, and a little "white lead," but no blende. The galena contained more silver in the western than in the eastern part of the mine.

BUCKLAND also refers to this mine (as the Gronant Mine), and gives the drift-section quoted on p. 30.*

The "gravel" referred to by M. MOISSENET appears to have been a glacial gravel, such as that described at Talargoch. (*See* also p. 47.) The sand is probably a disintegrated silicious vein-stuff, similar to that which fills the China Rake (p. 47). Parts of it are of a pure white, and so fine as to be impalpable; it contains lumps which generally crumble down when rubbed in the hand, but sometimes encloses cores of light blue chert, the form in which probably the material was originally deposited in the vein. In other parts the vein-stuff consists of a chert breccia in a cement of white calc-spar with blende. Specimens of the various vein-products, of black and light coloured banded chert, of light yellow and brown cherty sandstones with an occasional fragment of encrinital chert, and of black silicious shales, may all be seen in abundance in the pit-débris.

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* Reliquiæ Diluvianæ, p. 178.

Up to the close of 1861 more lead than zinc ore had been raised at Talacre; but subsequently, in the years 1867, 1870–71, and again in 1880–81, the periods during which the mine was in operation, the zinc ores were in preponderance, the tendency of the blende to replace the galena in the deeper parts being even more marked here than at Talargoch. The amount of lead ore raised since 1849 reaches a total of 3,575 tons 11 cwt. with a yield of silver varying from 8¾ to 9½ ounces per ton of lead. The total yield of zinc ores has been 5,556 tons 15 cwt., the returns in 1883 and 1884 being 645 and 720 tons. No lead has been raised since 1882.*

Other Mines.

Among the smaller mines may be mentioned the Golden Grove, which was being opened at the time of my survey. It is situated in a valley running past the house of this name towards Llanasa. I was informed† that a broad vein of spar ranging down the valley and hading to the north had been struck, with a direction apparently of about E. 10°–15° N. The limestone exposed in the sides of the valley is dark, and thin-bedded with chert-bands, and is probably on the same horizon as that of Carreg-y-frân.

Near the Volcnant Telegraph Station a joint ranging nearly east and west through the chert has been formerly worked. It is stated that this joint is a continuation of the Talacre Vein, but there is no evidence to confirm this view. A number of small shafts were sunk, and an adit-level was driven in the underlying Black Limestone from the edge of the marsh near Terfyn to a dingle on the west side of the Gwaenysgor road.

Further to the west, along the same line, a shaft known as the Nant-y-Mwyn Mine was sunk to a considerable depth in the Black Limestone, but no lode was discovered. The draining of the spring by which the tufa (p. 40) was deposited was attributed to these works. A powerful stream of water is carried off at the present time by the adit-level, which was driven under Nant Mill from near the site of Prestatyn Castle.

A shaft was commenced in the Drift on the north side of the road from Prestatyn to Gwaenysgor, but abandoned before reaching the rock. On Carreg-y-frân, a joint, running about E. 20° S., has been opened, and still shows traces of galena on the walls. With the intention of catching the intersection of this joint with veins supposed to range in this direction from Talargoch, a shaft was commenced in the year 1877 near the foot of the hill, but after traversing 204 feet of drift (p. 29) was abandoned without reaching the rock. From what has been previously said of the effect of the great Prestatyn fault, it may be gathered that it is not likely that a metalliferous rock would be met with in the low ground.

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* Mineral Statistics of the United Kingdom, by Robert Hunt.

† By the agent, Mr. Absalom Francis.

Further south (west of Gwaenysgor) levels have been driven into the hill-side along joints ranging about east and east-north-east, but without resulting in any discovery.

The workings of the Dyserth Mine were carried to a depth of 40 yards in a vein, which appears to have ranged N. 23° E. In the Mineral Statistics of 1869 a return of 16 tons of galena was made for this mine, and the ore is stated to have yielded 12 ounces of silver per ton of lead,—a high proportion for this district. A deposit of iron-pyrites in a stalactitic form was met with in the western workings, probably attributable to the Coal Measure shale thrown down on the west side of the great fault described on p. 21. Two veins, on one of which small trials have been made, may be traced over Cerrig Heilyn in a north-easterly direction; the southernmost is filled with a deposit of chert.

The Ash-tree Shaft on the south side of the waterfall was opened on a vein running a little east of north. As previously described (p. 23) the west workings encountered the Coal Measure shale.

The old lead-workings near Abergele are thus described by MR. TIDDEMAN.

Tyddyn Morgan.—A road running up to this house passes several shafts which have apparently been made in search of metal. Hæmatite and a little galena are visible in the waste-heaps. The run of the lode is E. 30° N.

Ffos-y-Bleiddiaid.—The northern end of the Castell Cawr hill has a great gash across it from top to bottom, which is named as above on the 6-inch Ordnance Map. It is evidently an old lead mine which has at some time been very extensively worked. The vein runs about E. 18° N., and has a considerable hade to the north. It has been approached by a level, to be seen in the fields to the north-east, and at the other side of the hill must have been worked under the field; for a large hole was formed in the middle of a crop of wheat, whilst I was in the district, by the falling in of the superficial deposits. Both of these veins are probably connected with the Siambr-Wen fault (p. 15).

Cefn-yr-ogof.—Two lead-veins cross this hill, and have been extensively worked. The northernmost has been entered from the Dulas Valley at Ty-newydd, and crosses the hill in a direction E. 20° N. towards a recess in the other side of the hill. A level has been driven to it from below the carriage-drive, and shafts are seen at intervals all the way. The other vein ranges for a much greater distance. It lies about 50 yards south of the former at the Dulas Valley end, and runs at first E. 20° S. with a hade to the south. It appears to have been a cave before it was opened out by the mining operations, and contains at its entrance beds of gravel cemented by stalagmite. The workings extend all the way to Gwrych Castle, a distance of one mile, and are well marked through the entire length. Through half its length it runs as stated, then for half the remainder of its course goes east, and for the rest comes out a little to the north-west of Gwrych Castle with a north-easterly range. An adit-level is to be seen here. In a little plantation amongst the fields, about half-way along the vein, are to be seen many small open shafts, only just about large enough to admit the body of an average-sized man.

Three hundred yards east of Tan-yr-ogof, a mining level crosses under the road to Llandulas; it has fallen in, in the field to the north, but its entrance may be seen on the shore close to the railway. It certainly was intended to drain one or other or both of these mines, but the direction which it seems to be taking would lead it past the northerly vein to the further. I saw no evidence of any rock but limestone having been met with in it. But very little of the resulting rubbish had been left by the sea.

R. H. T.

The following paragraph concerning these old mines, and the supposed Roman origin of the Ffos-y-Bleiddiaid is quoted by MR. R. HUNT* from the Records of Denbigh and its Lordship (JOHN WILLIAMS).

"At Abergele some Roman remains have been discovered. Here, as others have observed, are some of the most perfect Roman mines in the Kingdom. The mountain is cut across by a supposed Roman fosse, called Ffos-y-Bleiddiaid, or the Wolves' Fosse. . . . . In driving a level, towards the close of the last century, the miners discovered that the Romans had been deep in the bowels of the earth. They had followed the vein where it was large enough to admit a man, and where it opened into a large chamber, they had cleared it quite away. Some curious hammers and other tools were found, almost decayed to dust, with the golden hilt of a Roman sword. The level which drains those works partly supplies the town with water. . . . The mines at Cae'rgwaith, at the foot of the same hill, are comparatively modern, and were, we believe, very productive, until the water became too great for the means of drainage then applicable. . . . . Some forty years ago lead was raised in solid masses of several hundredweight each, out of a shaft about a furlong to the east of the last-named spot; but the speculators had not the means to compete with the constant influx of water. The old mines of Tyddyn-Morgan, in the same hill, were wonderfully productive a century back. . . . . Still farther west are the old mines of Cefngo'. . . . . Some thirty or forty years back, a large sum was expended in driving a level under this mountain, without meeting with anything worth the search and outlay."

HÆMATITE.

Hæmatite is believed to have been worked on Moel Hiraddug from a very early date. I was informed by Mr. GAGE of Rhuddlan, that some of the open-cast workings are attributed to the Romans, on the evidence of the discovery of a Roman sword and helmet, about 30 yards east of the Nickel and Cobalt Mine. At the Cwm Iron Mine a coin was picked up, stamped with the name Wilkinson, Iron-master of Cwm, and probably of some antiquity. The first return of ore made to the Mining Record Office was in the year 1860.

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* British Mining, p. 39, 8vo. *London*, 1884.

The ore occurs as nodules of dark, hard, almost pure peroxide of iron in a red ferruginous clay, on washing which away smaller grains containing about 1 per cent. of titanium oxide are left.* It is found in pockets or widened-out spaces in joints ranging about north-north-west. The pockets are irregular in shape, but generally bounded by curving vertical walls like those of a swallow-hole. Downwards they are usually terminated at a slight depth from the surface (rarely exceeding 60 yards) by the rapid closing in of the walls.† They are said to be richer in their contents near the top of the hill than at the base, where they are too poor to repay working.

One of the principal joints in this hill is known as the Main Joint, and has been followed for a distance of about 200 yards along the east slopes, and to a depth of 60 yards. It yielded ore containing on the average 50 per cent. of metallic iron. Other old workings occur near the top of the hill, and nearer the junction of the limestone with the Basement Beds on the south side.

The most extensive workings are situated at Marian near Cwm in the lowest beds of the limestone, and are known as the Cwm Iron Mine. The veins run in general about N. 15° W., and have the effect of throwing the limestone down to the east about 30 yards. The ore occurred partly in veins and partly in large chambers or pockets hollowed out in the lowest bed of limestone, where it rests upon the red shales and conglomerates of the Basement Beds. The underlying Wenlock Shale was entered to a depth of 20 yards in the No. 1 Shaft. The ground has now fallen in in the greatest confusion in consequence of the working out of the irregular deposits of ore.

The mine is stated to have yielded a total amount of 28,924 tons 17 cwts. in the years 1860–75 inclusive, the first return being 4,100 tons in 1860,‡ but little is now being done beyond sinking shallow trial-shafts on the numerous joints in the neighbourhood. I was informed that about 6 tons of copper ore were raised from a joint about 150 yards east south-east of Tyddyn-y-cyll.

An attempt was made to drive a day-level under this ground from the ravine north of Cwm, 150 yards south of the Marian road, but was abandoned after penetrating to a distance of about 130 yards in Wenlock Shale. Further north there have been several trials along the base of the limestone and in the red Basement Beds, but without any result.

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* See also H. BAUERMAN, Metallurgy of Iron. 5th Edition, 1882 ; p. 69.

† In the fissures of the walls of some of these cavities, snail shells thickly coated with tufa are abundant, and occasionally stags' horns have been found.

‡ Mineral Statistics of the United Kingdom, by R. HUNT.

In the years 1872–75 a poor ore (averaging about 30 per cent. of metallic iron) was worked at Henfryn. It was found in veins running a little west and a little east of north, and is associated with a manganiferous ochrey clay, and with traces of copper pyrites. The quantity of ore sold amounted to 340 tons 10 cwts.*

The trials for hæmatite, which have been made in the Basement Beds in the neighbourhood of Abergele, have already been referred to (p. 7).

Hæmatite with Nickel and Cobalt.

The ores of these metals have been worked on Moel Hiraddug since the year 1870. They were first observed by Mr. M. A. Gage, of Rhuddlan, (to whom I am indebted for much information concerning them,) and were described in 1882 by Mr. C. Le Neve Foster.† They occur in an irregular chamber or cavity in the limestone, originally opened out, as may be inferred from its rounded walls, by the solvent action of carbonated water along the line of a joint. While this cavity differs from the other metalliferous pockets on this mountain in opening out downwards after once showing a tendency to close, the joint also is distinguished by its direction, which is about N. 33° E. The deposit has been irregularly explored to a depth of about 240 feet.

The sides of the chamber are coated with iron oxide, in which are found occasional lumps of a hydrous sesquioxide of iron with a core of iron pyrites. Nickel and cobalt are present in small quantities in the core of pyrites, but not in the sesquioxide crust. Very rarely solid lumps of nickel and cobalt ore have been found, giving hopes of the discovery of a richer deposit, which, however, have not been fulfilled. The interior of the vein or cavity is filled by a red ferruginous clay with traces of nickel and cobalt, and containing hard lumps of iron oxide associated with nickel, cobalt, and manganese, the per-centage of the two first varying inversely as that of the last. The lumps are black and reniform, and usually are little more than pure iron oxide; smaller grains also are scattered through the mass of the clay, and are stated by Mr. Gage to be titaniferous. Analyses by Mr. Gage of three of the lumps of cobalt and nickel ore that have been found are given by Mr. Foster as follows:—

		No. 1.	No. 2.	No. 3.
Cobalt sesquioxide,	$Co_2\,O_3$ -	37·40	20·63	26·20
Nickel sesquioxide,	$Ni_2\,O_3$ -	8·58	6·85	10·35
Manganese binoxide,	$Mn\,O_2$ -	23·12	39·50	25·58
Iron sesquioxide,	$Fe\,O_3$ -	13·85	15·10	21·10
Copper oxide - - -		traces	traces	0·25
Silica - - - -		0·45	2·00	0·60
Alumina - - - -		0·10	0·50	0·18
Water - - - -		16·00	15·00	15·00
		99·50	99·58	99·26

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* Mineral Statistics of the United Kingdom, by R. Hunt.

† *Trans. Roy. Geol. Soc. Cornwall*, vol. x. part iv. p. 107.

And assays of five parcels of the ore sent to the smelters in Swansea are quoted as follows:—

	No. 1. Per cent.	No. 2. Per cent.	No. 3. Per cent.	No. 4. Per cent.	No. 5. Per cent.
Metallic cobalt -	1·0	1·1	1·2	1·6	1·8
Metallic nickel -	0·4	1·1	1·0	0·7	0·8
Total nickel and cobalt	1·4	2·2	2·2	2·3	2·6

An average assay is stated in the Mineral Statistics to give 2·05 per cent. cobalt, and 0·75 per cent. nickel; the highest per-centage amounting to 4·3 for the two together, in the year 1870, when the ore fetched 10*l.* 15*s.* per ton as compared with 4*l.* 18*s.* per ton in 1881. The total amount raised up to the close of 1884 was 1,158 tons 4½ cwt., the last return being 66 tons 8 cwt. for the year 1884, yielding on assay 1·1 per cent. cobalt, and 0·7 per cent. nickel.

It is considered by Mr. Gage that the vein products described above have been derived from the decomposition of cobaltiferous iron pyrites. The finding of lumps with an undecomposed core of such pyrites, and the occurrence of brown iron oxide pseudomorphous after iron pyrites, seems to confirm this view.

A similar joint, ranging about N. 30° E., has been observed about 200 yards further south, and has been tried to a slight depth with the result of discovering traces of nickel and cobalt ores. In another joint, however, where iron ores had been worked, manganese occurred abundantly without traces of these metals.

Traces of cobalt have been noticed in the manganese oxide of the Nant uchaf Mine near Abergele, but not in marketable quantity. The Moel Hiraddug Mine is the only source of this ore now being worked in the British Isles.

Hæmatite with Copper.

Allusion has already been made to the finding of a small quantity of copper pyrites near Tyddyn-y-cyll, and of traces at Henfryn. A more extensive deposit has been worked in a powerful vein at Graig-fawr, near Talargoch. The vein is a part of the great Prestatyn fault which ranges in a south-south-westerly direction, and hades to the west-north-west. A shaft, now fallen in, was sunk upon it to a depth of 40 yards, and a brown decomposed iron ore containing green lumps of carbonate and oxide of copper was extracted. The lumps, fragments of which are still to be seen in the débris, are said to have contained about 16 per cent. of metallic copper, the ore in bulk averaging about six per cent. It has probably resulted from the decomposition of copper pyrites. Both to the north and south of the shaft there are old open-cast workings in the same vein, which are attributed to the "old men." Pebbles of copper ore are stated by Dr. Buckland to have occurred also with the gravel lead-ore at Talargoch.*

PYROLUSITE (DIOXIDE OR BLACK OXIDE OF MANGANESE).

The black oxide of manganese occurs as an amorphous powder in hollows along a very ill-defined joint in the Pentre chert-quarry near Gronant, but not in sufficient bulk to have led to any trials being made upon it. Its occurrence in small quantities in connection with the hæmatite deposits on Moel Hiraddug has already been referred to. This ore, associated with hæmatite, has been lately worked at Nant uchaf,† about two miles south-west of Abergele, where it occurred in a thick mass in the Carboniferous Basement Beds. The mine is now abandoned.

ON THE PROBABILITY OF THE OCCURRENCE OF COAL UNDER THE BUNTER SANDSTONE.

The Carboniferous rocks of the Vale of Clwyd, as has been shown in the previous pages, are in the form of a trough, faulted in among the Silurian rocks. On the east of the trough runs the great Vale of Clwyd fault, throwing down the newer Carboniferous rocks to the west; on the west side of the trough there are a number of faults, all throwing the beds down to the east. It will be clear then that the newest Carboniferous rocks will be found in the ground that separates these two systems of faults; and the question arises, whether it is probable that the productive Middle Coal Measures of the Flintshire Coal-field occur in this area. The whole of the ground being overspread by Drift and Bunter Sandstone, and the only trials (the Foryd and Prestatyn Bore-holes, p. 25) having been made without scientific assistance, it is possible only to infer the nature of the underlying measures from the scanty observations that are available along the borders of the Vale.

On the east side the great Vale of Clwyd fault is seen in the Talargoch Mine (p. 21) to introduce measures with a thin coal, which are probably the Lower Coal Measures of the Flintshire Coal-field. These should in natural order be succeeded by the sandstone of Gwespyr (Gannister Series of Lancashire), and the sandstone by the productive Middle Coal Measures of Picton and Mostyn, the united thicknesses of Lower Coal Measure shales and sandstones amounting to about 300 feet. The dip of the beds as observed in the mine is towards the north-west, at a sufficiently steep angle to bring on the succession referred to within a short distance. But it is probable that the inclination of the beds decreases rapidly further away from the great fault. Even supposing this to be the case, there would appear to be room for the succession between Dyserth and Rhyl, a distance of nearly 3½ miles.

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* Reliquiæ Diluvianæ, p. 178.

† In Quarter-sheet 79 S.W.; in the Explanation of which it will be more fully described.

On the west side near Abergele the upper boundary of the limestone is hypothetical (p. 25); but there is no doubt, from the general strike and dip of the limestone range, that it is succeeded towards the north-north-east by newer Carboniferous rocks, which would probably also dip in this direction.*

Having regard to the positions of the faults, and direction of the dip on the two sides of the Vale, it appears that the deepest part of the trough should lie between the mouth of the Clwyd and Prestatyn, between the two bore-holes at the Foryd and near Prestatyn (indicated on the map); and that in this deepest part there is a reasonable probability that Middle Coal Measures may occur. The depth of the overlying superficial deposits in this area would probably average about 80–100 feet, and of the Bunter Sandstone about 500 feet, along the sea-coast. As to the southern limit of this supposed patch of Middle Coal Measures, there is no evidence. It is not probable that they extend beyond, if so far as, the southern margin of this Map.

QUARRIES, BRICK-PITS, &C.

The principal limestone quarries are at Llandulas, and Dyserth (p. 10). The white limestone used in building Bodlewyddan church is found in the hills south of Abergele. The chert-quarry at Gronant, and the white sand of Talargoch, have already been referred to (pp. 19 and 47). Bricks are made from the red Boulder Clay in the Vale of Clwyd and Colwyn Bay, and near Rhyl also of the marsh clay (tidal slutch) on the south side of the town.

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* The dip of the purple sandstones in the nearest exposure, near St. Asaph, was found by MR. TIDDEMAN to be to the south. But, bearing in mind the general structure of the Vale, one would be inclined to regard this as merely local, especially as it occurs near a line of fault.

APPENDIX I.

Observations on Underground Temperature in the Talargoch Lead Mine.

These observations were made in company with Mr. A. O. Walker, and with the assistance of Mr. Lean, the captain of the mine. The thermometers used were slow-acting instruments, by Negretti and Zambra, as constructed for the Committee appointed by the British Association for the investigation of underground temperatures.* The errors of the thermometers had been determined at Kew, and are corrected in the readings given below. The observations were made as follows:—in a newly opened part of the mine a hole was bored in the side of the level to a depth of 24 inches, and plugged up with clay and dry rag. After the lapse of some hours the thermometer was inserted, and the hole again plugged as before. After four or six days interval the thermometer was taken out, read, and inserted as before. A second reading was made a few days later. If the two readings were found to agree, the observation was considered reliable. The positions of the observations are indicated on the Map (*see* Plate) by corresponding letters.

Talargoch Vein.

	Feet from surface.	Temperature.	Rate of Increase.
A.	465	53·35°	1° in 77 feet.
B.	1041	60·80°	

South Joint.

C.	555	52·90°	1° in 97½ feet.
D.	660	54·00°	

In solid rock, near Walker's Shaft (1000 *yards from the preceding*).

E.	630	58·8°	1° in 54¼ (calculated).
F.	636	58·8°	

The following table gives the temperatures as calculated for the same depth (630 feet) in the three localities.

Talargoch Vein (calculated).	South Joint (calculated).	Solid rock (Walker's Shaft) (observed).
55·46°	53·97°	58·8°

The great differences in the rate of increase of temperature in different parts of the mine may perhaps be due to the very faulty nature of the ground. In some cases the rock overlying the point of observation was principally shale, in others limestone, in part thick-bedded and massive, in part thin-bedded and shaly. The observations near Walker's Shaft were near the Vale of Clwyd fault, in which there is abundance of iron pyrites, and the water from which is charged with sulphuretted hydrogen. It is possible that chemical action may be now proceeding and locally raising the temperature here. The temperature of the water being pumped from the 256 yard level was 63°.

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* For whom the observations were originally made. See *Rep. Brit. Assoc.* for 1880, p. 26; for 1881, p. 90.

APPENDIX II.

LIST OF WORKS ON THE GEOLOGY, &c. OF DENBIGHSHIRE AND FLINTSHIRE.

By William Whitaker, B.A., F.G.S., Assoc. Inst. C.E., and Aubrey Strahan, M.A., F.G.S.

List of Authors alphabetically arranged.*

Acton, E. H. 1881.
Aikin, A. 1797.
Aitken, J. 1870.
Anon. 1819, 1831, 1863, 1874.
Ansted, Prof. D. T. 1878.
Aveline, W. T. **1850–55**, **1858**, **1885**.

Bamber, H. K. 1875.
Barrat, J. 1860.
Bauerman, H. **1858**.
Beaumont, E. de. 1825.
Beckett, H. 1864, 1873.
Bingley, Rev. W. 1814.
Binney, E. W. 1860, 1867.
Bishop, W. 1822.
Bonney, Rev. T. G. 1867, 1869.
Bostock, R. 1868.
Bowman, J. E. 1837, 1841.
Brady, H. B. 1873.
Bretherton, E. 1856.
Buckland, Rev. Prof. W. 1823, 1843, 1844.
Burr, F. 1837.

Clarke, Dr. E. D. 1817.
Coal Commission. 1871.
Conybeare, Rev. W. D. 1822, 1834.
Croft, Rev. C. 1882.
Crosskey, Rev. H. W. 1875, 1877, 1878.

Da Costa, E. M. 1758.
Darbishire, R. D. 1868.
Darlington, G. 1862.
Davies, D. C. 1859, 1864, 1865, 1870, 1873, 1876, 1877, 1881, 1883.
Davies, W. 1813.
Davidson, T. 1861, 1863.
Dawkins, Prof. W. B. 1870, 1874, 1880.
De Rance, C. E. 1882, 1883, **1885**.
Dickinson, J. 1871, 1874.
Duckworth, H. 1861.
Dufrénoy, P. A. 1825.

Eskrigge, R. A. 1880.
Etheridge, R. 1881, 1882.
Evans, Rev. J. 1812.
Everett, Prof. J. D. 1880, 1882.
Eyton, Miss. 1866, 1868.

Fairbairn, W. 1842.
Farey, J. 1815.
Flight, Dr. 1872.
Foster, Dr. C. Le Neve. 1882.
Fox, R. W. 1832
Frankland, Prof. E. 1874.

Green, Prof. A. H. 1867.
Griffith-Boscawen, A. S. J. 1883.
Griffith, N. R. 1870.

Haime, J. 1852.
Hall, C. R. 1865.
Hall, H. F. 1866, 1870.
Harrison, W. J. 1882.
Henwood, W. J. 1871.
Hicks, Henry. 1876, 1881, 1882, 1885.
Higgins, W. M. 1868.
Höfer, H. 1884.
Hopkins, J. 1853.
Hughes, Prof. T. McK. 1874, 1877, 1879, 1882.
Hull, E. **1850**, **1855**, **1858**, 1860, 1862, 1869, 1881.
Hunt, R. **1855–82**, 1868, 1884.

Jukes, J. B. **1850–55**, 1865.

Lucy, W. C. 1873.

Mackintosh, D. 1866, 1868, 1869, 1872, 1873, 1874, 1876, 1877, 1879, 1881, 1882.
Marr, J. E. 1880, 1883.
Maskelyne, Prof. N. S. 1872.

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* The dates printed thus **1850** are those of the publications of the Geological Survey and Mining Record Office.

Maw, G. 1865, 1866, 1867, 1868.
M'Coy, Prof. F. 1851.
Meade, R. 1877, 1882.
Mello, Rev. J. M. 1867.
Milne Edwards, Prof. H. 1852.
Moissenet, M. L. 1857.
Moore, C. 1870.
Moore, T. J. 1867.
Morris, Prof. J. 1862.
Morton, G. H. 1866, 1869, 1870, 1873, 1874, 1876, 1877, 1878, 1879, 1881, 1882, 1883.
Morton, J. C. 1874.
Mostyn, R. 1677.
Murchison, Sir R. I. 1839, 1854, 1867.

Ness, W. 1865.
Nixon, E. 1866.

Page, Dr. D. 1875.
Parry, R. 1861.
Parry, Samuel. 1876.
Pennant, T. 1757, 1778, 1796, 1810.
Percy, Dr. J. 1875.
Phillips, William. 1822.
Price, J. 1874.
Prichard, Dr. J. C. 1815.
Prosser, W. 1865.
Purton, W. 1866.

Ramsay, Sir A. C. **1850–52, 1854, 1866**, 1863, 1871, 1872, 1876, **1881.**
Reade, T. Mellard. 1885.
Ricketts, Dr. C. 1867, 1872.
Riley, E. 1862, 1872.
Rivers Pollution Commission. 1874.
Roberts, D. W. 1870.
Roberts, G. E. 1858, 1862.
Rowlandson, T. 1847.
Ruddy, T. 1879.

Salter, J. W. **1866**, 1873, 1882.
Sedgwick, Rev. Prof. A. 1838, 1841, 1843, 1844, 1845, 1847, 1852, 1855.
Selwyn, A. R. **1850–52, 1854, 1855.**
Sharpe, D. 1846.
Shrubsole, G. W. 1879, 1881.
Smith, Dr. R. A. 1884.
Smythe, W. W. **1850.**
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Strahan, A. 1879, **1882, 1885.**
Stirrup, Mark. 1881.
Symonds, Rev. W. S. 1872.

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Traill, Dr. T. S. 1821.
Trimmer, J. 1838, 1839.

Vivian, W. 1872.

Walker, A. O. 1878, 1879.
Wallace, A. R. 1867.
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Whitaker, W. 1880.
Williams, D. H. **1850, 1858.**
Williams, J. J. 1876.
Williams, W. M. 1865.
Wright, T. 1862.
Wynne, Mrs. W. 1882.

Yates, Rev. J. 1825.

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79, S.W. (Denbigh, St. Asaph). By W. T. Aveline. The Lodes by W. W. Smyth. 1850.

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31, 32, and 33. Section from the Suspension Bridge, Menai Straits [to the River Camlad, 6 miles S.E. of Welshpool]. By A. C. Ramsay, A. R. Selwyn, W. T. Aveline, and J. B. Jukes. 1854.

35. From Cwm Cywen, 4½ miles N.E. of Bala, over Cader Berwyn, the Breidden Hills . . . By J. B. Jukes and W. T. Aveline. 1853.

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39. Section from Arenig Fawr to the Coal Measures near Wrexham. By J. B. Jukes and W. T. Aveline. 1855.

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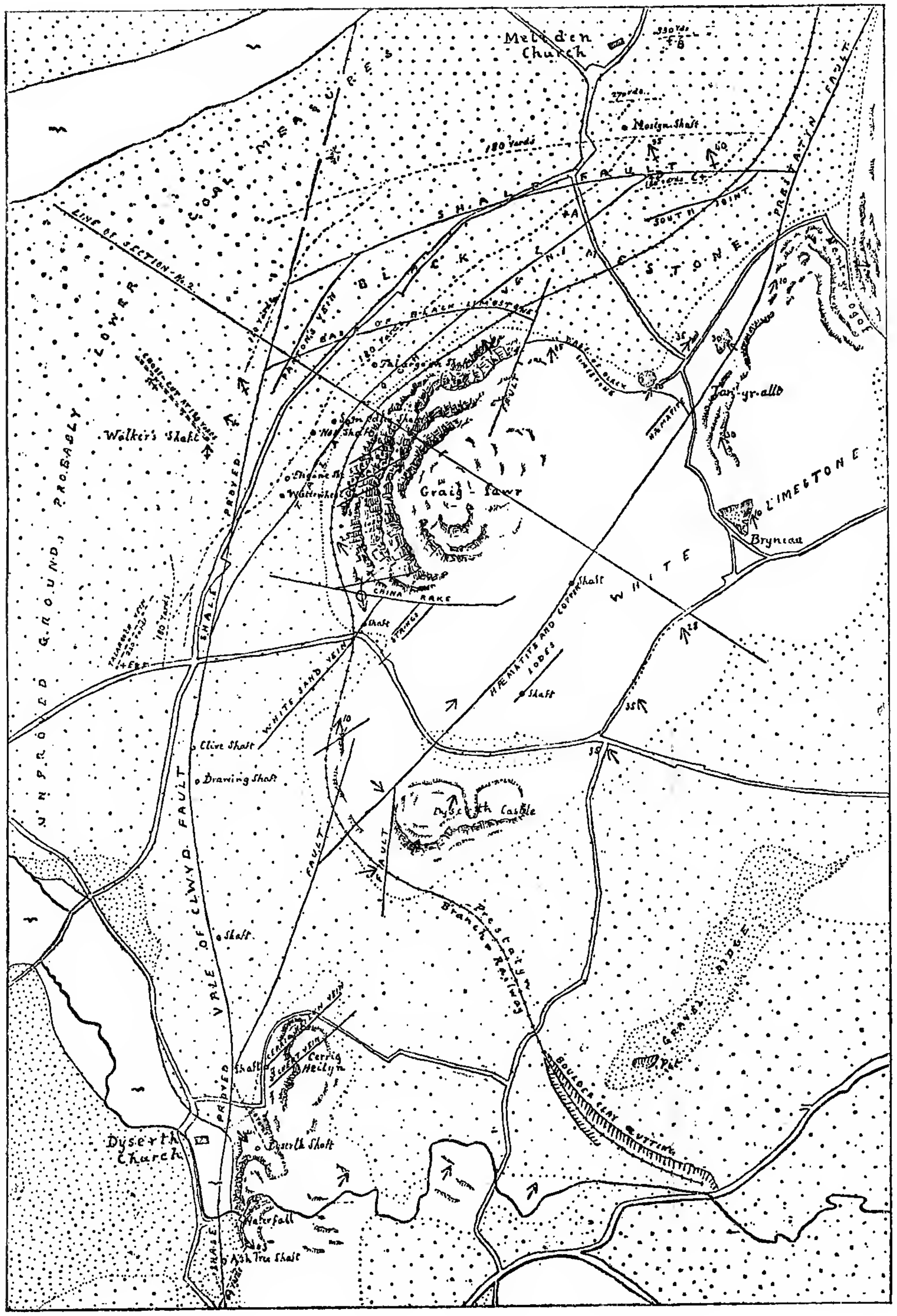
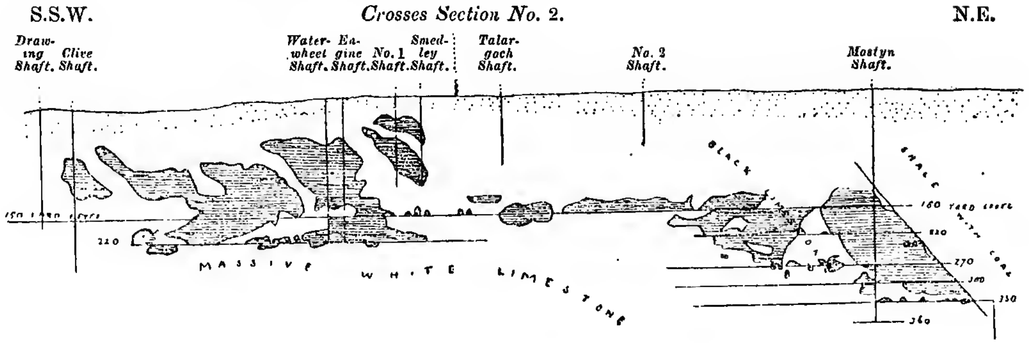
Map and Sections of the Talargoch Mine and Neighbourhood.

By A. Strahan.



Section No. 1.

Showing the Distribution of the Ore in the Talargoch Vein.



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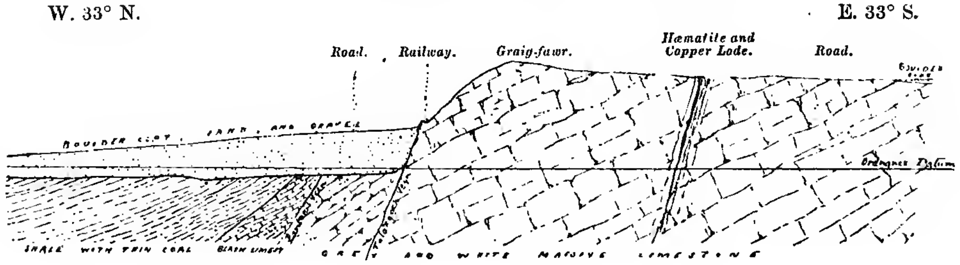
In the Direction of the Dip and across the Veins.



Scale for Map and Sections (Vertical and Horizontal).

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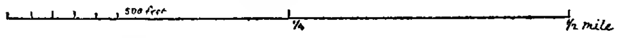

~ Indicates Alluvium.

∴ „ Boulder Clay.

⁘ „ Sand and Gravel.

—ı— „ Position of Veins or Faults at the Surface.

.180 yds. „ „ „ „ at depth stated

↗ Indicates dip of Strata observed on the Surface.

↗ „ „ „ Underground.

+A +B mark the spots beneath which Underground Temperature has been observed.

↗ denotes Glacial Striæ.

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Warwickshire, 62 (NE SE), 63 (NW SW), 54 (NE), 53 (NW).
Yorkshire, 88 (NE, SE), 87 (SW), 92 (SE), 93 (SW).

GEOLOGICAL MAPS.

Scale, six inches to a mile.

The Coal-fields and other mineral districts of the N. of England are published on a scale of six inches to a mile, at 4*s.* to 6*s.* each. MS. Coloured Copies of other six-inch maps, not intended for publication, are deposited for reference in the Geological Survey Office, 28, Jermyn Street, London.

Lancashire.

Sheet.
15. Ireleth.
16. Ulverstone.
17. Cartmel.
22. Aldingham.
47. Clitheroe.
48. Colne, Twiston Moor
49. Laneshaw Bridge.
55. Whalley.
56. Haggate.
57. Winewall.
61. Preston.
62. Balderstone, &c.
63. Accrington.
64. Burnley.
65. Stiperden Moor,
69. Layland.
70. Blackburn, &c.
71. Haslingden.
72. Cliviger, Bacup, &c.
73. Todmorden.
77. Chorley.
78. Bolton-le-Moors.
79. Entwistle.
80. Tottington.
81. Wardle.

Sheet.
84. Ormskirk, St. Johns, &c.
85. Standish, &c.
86. Adlington, Horwick, &c.
87. Bolton-le-Moors.
88. Bury, Heywood.
89. Rochdale, &c.
92. Bickerstaffe.
93. Wigan, Up Holland, &c.
94. WestHoughton, Hindley.
95. Radcliffe, Peel Swinton.
96. Middleton, Prestwich.
97. Oldham, &c.
100. Knowsley, Rainford, &c.
101. Billinge, Ashton, &c.
102. Leigh, Lowton.
103. Ashley, Eccles.
104. Manchester, Salford, &c.
105. Ashton-under-Lyne.
106. Liverpool, &c.
107. Prescott, Huyton, &c.
108. St. Helen's, Burton Wood.
109. Winwick, &c.
111. Cheedale, Stockport, &c.
112. Stockport, &c.
113. Part of Liverpool, &c.

Durham.

1. Ryton.
2. Gateshead.
3. Jarrow.
4. S. Shields.

5. Greenside.
6. Winlaton.
7. Washington.
8. Sunderland

Durham—*continued.*

Sheet.
9. ———
10. Edmondbyers.
11. Ebchester.
12. Tantoby.
13. Chester-le-Street.
16. Hunstanworth.
17. Waskerley.
18. Muggleswick.
19. Lanchester.
20. Hetton-le-Hole.
22. Wear Head.
23. Eastgate.
24. Stanhope.

Sheet.
25. Wolsingham.
26. Brancepeth.
30. Benny Seat.
32. White Kirkley.
33. Hamsterley.
34. Whitworth.
38. Maize Beck.
41. Cockfield.
42. Bishop Auckland.
46. Hawksley Hill House.
52. Barnard Castle.
58. Winston.

Northumberland.

44. Rothbury.
45 Longframlington.
46. Broomhill.
47. Coquet Island.
54. Longhorsley.
55. Ulgham.
56. Druridge Bay.
63. Netherwitton.
64. Morpeth.
65. Newbiggin.
72. Bedlington.
73. Blyth.

80. Cramlington.
81. Earsdon.
82. NE. of Gilsland.
88. Coadley Gate.
87. Heddon.
88. Long Benton.
89. Tynemouth.
91. Greenhead.
92. Haltwhistle.
93. HaydonBridge.
94. Hexham.
95. Corbridge.
96. Horsley.
97. Newcastle.

98. Walker.
101. Whitfield.
102. Allendale Town.
103. Slaley.
105. Newlands.
106. Blackpool Br.
107. Allendale.
108. Blanchland.
109. Shotleyfield.
110. Wellhope.
111. Allenheads.
112.

Cumberland.

55. Searness.
58. Skiddaw.
63. Thackthwaite.
64. Keswick.
65. Dockraye.

69. Buttermere.
70. Grange.
71. Helvellyn.
74. Wastwater.
75. Stoocthwaite Fell.

Westmorland.

2. Tees Head.
6. Dufton Fell.

12. Patterdale.
18. Near Grasmere.

25. Grasmere.
38. Kendal.

Yorkshire.

7. Redcar.
9. ———
12. Bowes.
13. Wycliffe.
20. Lythe.
24. Kirkby Ravensworth.
25. Aldborough.
32. Whitby.
33. ———
38. Marske.
39. Richmond.
46. ———
47. Robin Hood's Bay.
53. Downholme.
68. Leybourne.
82. Kidstones.
84. E. Witton.
97. Foxup.
98. Kirk Gill.
99. Haden Carr.
100. Lofthouse.
115. Arncliffe.

116. Conistone Moor.
133. Kirkby Malham.
184. Dale End.
185. Kildwick.
200. Keighley.
201. Bingley.
202. Calverley.
203. Seacroft.
204. Aberford.
215. Peeke Well.
216. Bradford.
217. Calverley.
218. Leeds.
219. Kippax.
231. Halifax.
232. Birstal.
233. East Ardsley.
234. Castleford.
246. Huddersfield.
247. Dewsbury.
248. Wakefield.
249. Pontefract.
250. Darrington.

260. Honley.
261. Kirkburton.
262. Darton.
263. Hemsworth.
264. Campsall.
272. Holmfirth.
273. Penistone.
274. Barnsley.
275. Darfield.
276. Brodsworth.
281. Langsell.
282. Wortley.
283. Wath upon Dearne.
284. Conisborough.
287. Low Bradford.
288. Ecclesfield.
289. Rotherham.
290. Braithwell.
293. Hallam Moors.
295. Handsworth.
298. Laughton - en - le-Morthen.
299. ———
300. Harthill.

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